ESP-1

Eberline Smart Portable Technical Manual

Eberline

A subsidiary of
Thermo Instrument
Systems Inc.

Price List

Repair Calibration

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EFFECTIVE January 1, 1993
Prices are F.O.B. Santa Fe, New Mexico
Subject to change without notice
Terms: ¾ of 1% 10, net 30 days
Minimum order $40.00

The prices quoted herein do not include state, gross receipts, or local sales tax. The tax will be added as a separate item in the event that the transaction is determined to be taxable.

Eberline *A subsidiary of* ***Thermo Instrument*** *Systems Inc.*

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GENERAL INFORMATION

Instruments for repair or calibration should be packaged, marked, or otherwise prepared in accordance with good commercial practices and shipped F.O.B. destination freight prepaid to one of the Eberline facilities below.

Repair and Calibration Facilities

Eberline Instrument Corporation
504 Airport Road
Santa Fe, NM 87504-2108
Attn: Western Service Center
(505) 471-3232
1-800-274-4212

Eberline Instrument Corporation
312 Miami Street
West Columbia, SC 29169
Attn: Eastern Service Center
(803) 822-8843
1-800-234-4212

Normal turn-around time for repair (Eberline instruments) is fifteen working days.

Normal turn-around time for calibration (Eberline instruments) is seven working days.

Prices (Subject to change without notice)

Certified calibration (basic portable instruments)(2 points/range)	
Unit and one probe	$98.00
Second probe	49.00
Third or fourth probe (Limited to 4 probes per instrument)	27.00
ALPHA-3, ALPHA-5, AMS-3, HFM's, Portal Monitors, RM-22, SAM-2, WLM-1A, ESP-2, ERM-2, SRM-200, 6112B, 6112D (certified calibration) [Some other manfacturers portable instruments].	155.00
RGM-2 (certified calibration)	435.00
RGM-3 (certified calibration)	255.00
As found readings on any of the above, a charge of 50% of calibration rate shall be made.	
Calibrate "non-removeable" contaminated instruments	QUOTE
Services Contracts (Eberline equipment)	QUOTE
Technical Specification writing and Consultation	QUOTE
Service Engineer at Customers Site	$1,025.00/day plus expenses at cost +10% adm.
-Over 8 hours or Saturday and Sunday	192.00/hr
-Eberline Holidays	256.00/hr
Consulting	1,100.00/day
Repair rate (plus calibration and parts at list price)	90.00/hr
Repair "non-removeable" contaminated instruments	100.00/hr
Expediting Fee	85.00/ instrument
Accredited secondary standards laboratory calibration (Cs^{137} and Co^{60} photon) [Santa Fe Only]	QUOTE

Note: Repair and Calibration time on non-Eberline instruments is subject to availability of parts and literature for the specific instrument.

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ESP-1
TABLE OF CONTENTS

SECTION I. GENERAL 1
- A. PURPOSE AND DESCRIPTION 1
- B. SPECIFICATIONS 2
  - 1. Mechanical 2
  - 2. Operating Temperatures: 2
  - 3. Voltages 2
  - 4. Detectors 2
  - 5. Readout 2
  - 6. Alarm 2
  - 7. External Controls 2
  - 8. Internal Controls 2
  - 9. Power Supply 3

SECTION II. SIMPLIFIED OPERATING INSTRUCTIONS 1
- A. INTRODUCTION 1
  - 1. General 1
  - 2. User Calibration 2
  - 3. Calibrations Required by Regulatory Agencies 4
- B. PRELIMINARY INSTRUCTIONS 4
  - 1. Set Up the ESP-1 and Detector 4
  - 2. Turn the Instrument *ON* and *OFF* 5
  - 3. Determine Low Battery Condition and Battery Replacement 5
- C. OPERATION IN THE RATE METER MODE 6
  - 1. Analog Bar Graph 6
  - 2. Numerical Value of Count Rate 6
  - 3. Alarm 6
  - 4. Overrange Indication 7
- D. OPERATION IN SCALER MODE 7
- E. OPERATION IN INQUIRY/CALIBRATION MODE 9
  - 1. Selecting of Inquiry/Calibration Mode and Setting the Alarm 9
  - 2. Changing Units 9
  - 3. Setting the Calibration Constant (CC) 11
  - 4. Setting the Dead Time (DT) 12
  - 5. Setting the High Voltage for the Detector of Choice 13
- F. SIMPLE TROUBLESHOOTING 15

SECTION III. DETAILED OPERATION 1
- A. DESCRIPTION OF CONTROLS AND CONNECTORS 1
  - 1. Operator Controls - External (figure 2-1) 1
  - 2. Operator Controls - Internal (figure 3-1) 3
- B. PREPARATION FOR USE AND OPERATIONAL CHECK 4
- C. OPERATING THE INSTRUMENT 4
  - 1. Rate Meter Mode 4
  - 2. Scaler Mode 5
  - 3. Inquiry/Calibration Mode 7

TABLE OF CONTENTS

SECTION IV. THEORY OF OPERATION 1
- A. GENERAL 1
- B. FUNCTIONAL THEORY 1
  - 1. Detector 1
  - 2. High-Voltage Supply 1
  - 3. Amplifier/Discriminator 1
  - 4. Speaker/Alarm 1
  - 5. Microcomputer 1
  - 6. Low-Voltage Supply 2
- C. OPERATIONAL THEORY 2
  - 1. Low-Voltage Power Supply 2
  - 2. High-Voltage Power Supply 3
  - 3. Amplifier/Discriminator 3
  - 4. Speaker 3
  - 5. Keyboard 4
  - 6. Microcomputer 4

SECTION V. MAINTENANCE 1
- A. CALIBRATION 1
  - 1. General 1
  - 2. High Voltage 1
  - 3. Instrument/Detector Quality 1
  - 4. Rate Meter Calibration 4
- B. PREVENTIVE MAINTENANCE 6
  - 1. Periodic Maintenance 6
  - 2. Battery Replacement 6
  - 3. Right-Side Access 7
- C. CORRECTIVE MAINTENANCE 7
  - 1. Disassembly/Assembly 7
  - 2. Troubleshooting 11

SECTION VI. PARTS LIST 1

SECTION VII. DIAGRAMS 1

SECTION VIII.DETECTORS AND ACCESSORIES 1

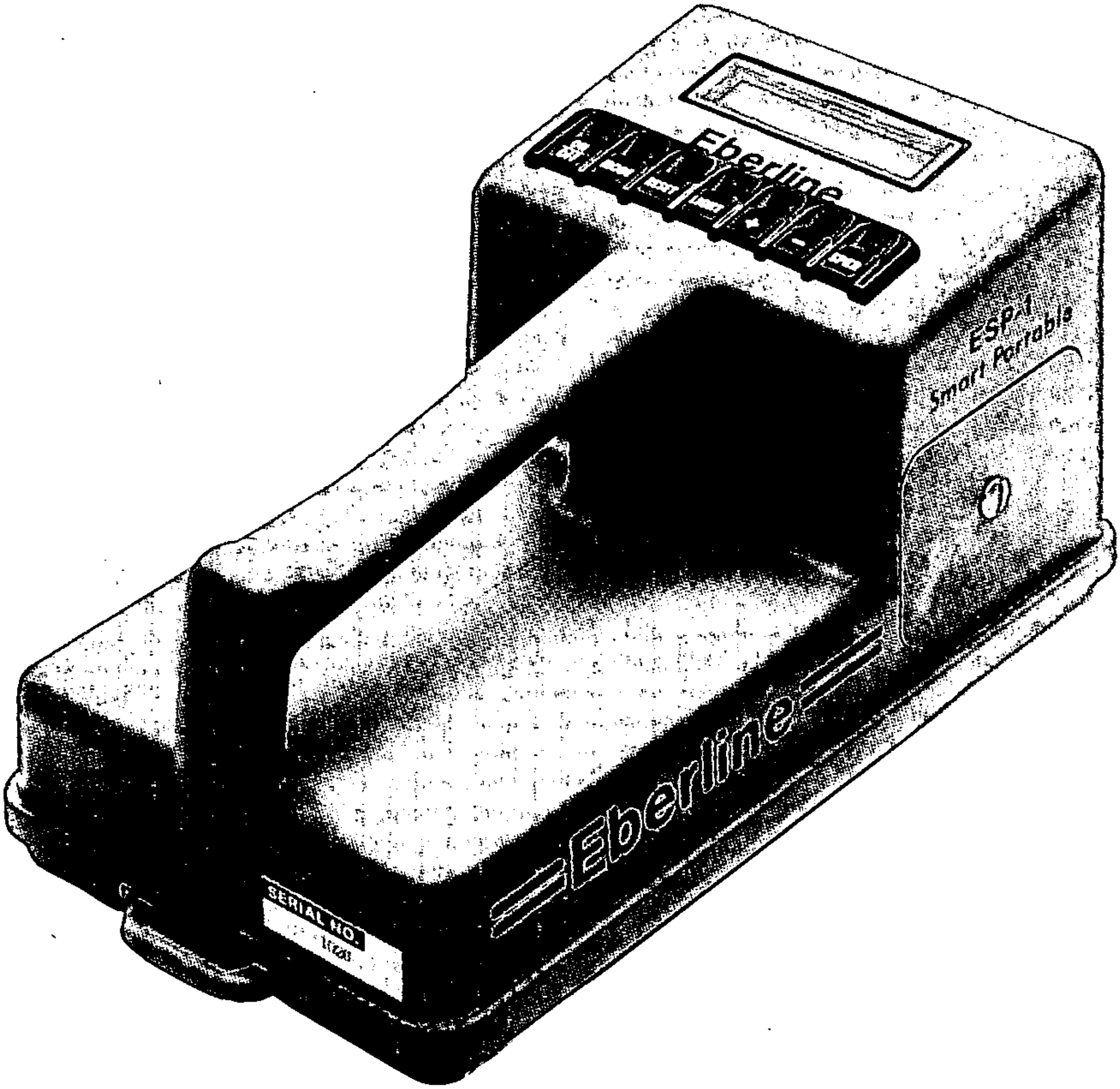


Figure 1-1. Model ESP-1

SECTION 1

MODEL ESP-1

SECTION I. GENERAL

A. PURPOSE AND DESCRIPTION

The Eberline Smart Portable (ESP-1) is a microcomputer-based portable radiation survey instrument designed to operate with most Eberline radiation detectors. The ESP-1 can display the data from these detectors in radiation units as selected and calibrated by the user. In addition, the ESP-1 has a built-in speaker, with earphone output capability, available for use by the operator.

The external controls used to operate the ESP-1 are located on the face of the instrument in a single row of seven square push button switches. Two are "push on-push off" switches and the remaining five are "push on-normally off." Internal controls, accessible through a door on the right side of the instrument, enable the user to adjust and select other functions that are available to the operator. The internal controls consist of four potentiometers and four switches.

The ESP-1 readout is a liquid crystal display (LCD) located on the face of the instrument.

The power supply for the ESP-1 is fully self-contained and consists of six "C" cells.

Several Eberline probes and detectors are available for use with the ESP-1. The Eberline detectors recommended for use with the ESP-1 are included in a table at the end of the manual.

The ESP-1 has three operating modes, Rate Meter, Scaler, and Inquiry/Calibration. The detector signal is input to the computer and converted to count rate. The basic unit is counts per second. The *Rate Meter Mode* provides the operator with a dual representation of count rate. Count rate is displayed as an analog bar graph, the length of which is proportional to the activity at the detector, and as a numerical value expressed in the applicable radiation units. An audio alarm feature alerts the operator when an alarm setting has been exceeded. To enhance accuracy, the ESP-1 provides both a slow and a fast range of time response, each of which varies automatically with count rate.

The *Scaler Mode* allows the operator to select a "counting period" over which the computer integrates the detector signal. On the first line of the LCD the instrument displays the time remaining in the counting period. The second line shows cumulative "events" (the basic unit) or cumulative radiation units, e.g., "R." At the end of the counting period the instrument displays the length of the counting period and the total number of events or radiation units counted. The scaler mode may be disabled by an internal switch.

An *Inquiry/Calibration Mode* is also available. This mode is used to enter and adjust various parameters as necessary to permit optimum operation of the instrument with several types of probes. In the Inquiry/Calibration Mode, the ESP-1 is actually measuring in the Rate Meter Mode, with the bar graph and the alarm suppressed and with the slow response time selected to enhance accuracy. This mode may also be disabled by an internal switch.

B. SPECIFICATIONS

1. **Mechanical** (with batteries, excluding probe)

   a. Overall Dimensions (including all protrusions): 10.25 inches x 5.0 inches x 5.0 inches (26.0 cm x 12.7 cm x 12.7 cm).

   b. Weight: Approximately 3.8 pounds (1.72 kg).

2. **Operating Temperatures:** -20°C to +50°C (-4°F to +122°F)

3. **Voltages**

   a. Low Voltage: 5 Vdc.

   b. High Voltage (detector bias voltage): 350 to 2300 Vdc, set by the person calibrating the instrument to the bias voltage required for the detector being used.

4. **Detectors**

   Most Eberline GM, proportional, or scintillation detectors for alpha, beta, gamma, or neutron activity may be used on the ESP-1. The detectors recommended are described at the end of this manual. The detectors connect to the ESP-1 via an MHV-series coaxial connector located on the front of the instrument.

5. **Readout**

   a. Two lines of 16 alphanumeric characters presented on liquid crystal display (LCD).

   b. Character size: H = 0.175 inch (4.45 mm); W = 0.124 inch (3.15 mm).

   c. Bar graph resolution: 1 in 48 (2.1 percent).

6. **Alarm:** A 2000-Hz audio tone from the speaker.

7. **External Controls**

   A single row of seven 3/8-inch-square push-button switches on 1/2-inch centers across the face of the instrument. From left to right, they are:

   a. *ON/OFF*: Press on - press off
   b. *MODE*: Press on - normally off
   c. *RESET*: Press on - normally off
   d. *LIGHT:* Press on - normally off
   e. +: Press on - normally off
   f. -: Press on - normally off
   g. *SPKR:* Press on - press off

8. **Internal Controls**

The internal controls consist of four potentiometers and four switches accessible through the door on the right side of the instrument. They are:

a. *LV* (Low Voltage): Potentiometer

b. *DISCR* (discriminator): Potentiometer

c. *HV* (High Voltage): Potentiometer

d. *VO* (viewing angle): Potentiometer

e. *SPKR* (speaker): One switch (three positions)

f. *MASK:* Two SPST switches

g. *TEST:* Switch

9. Power Supply

The ESP-1 uses six "C" cell batteries. In the ESP-1, the end-of-life (EOL) voltage per cell is approximately 0.93 Vdc using carbon-zinc cells. Six carbon-zinc batteries provide approximately 250 hours of continuous use (excluding display lighting). Operation with alkaline cells provides even longer battery life. The ESP-1 senses the low battery condition at approximately 0.95 Vdc/cell and signals the user by blinking the first character on the display. This indicates that at least 4 hours of operation remain before the end of battery life. The ESP-1 is programmed to turn itself off after it has operated for 2 hours under the "low voltage" condition (first character blinking). The instrument can be turned on by the operator and will operate for another 2 hours after which it will turn itself off again.

The ESP-1 computer always has a supply of power to the memory so that data will be retained when the power switch is off. The typical battery drain with power off is less than 10 µA; therefore, the batteries should be changed at least once a year. To allow battery change without loss of memory, the ESP-1 uses a 0.047-F capacitor to supply power to the computer. **This allows about 20 minutes to change batteries.**

SECTION 2

SECTION II. SIMPLIFIED OPERATING INSTRUCTIONS

A. INTRODUCTION

1. General

This section is intended to provide the first time user with a quick guide to what the ESP-1 does and how to operate it. Much of the information included here occurs in later sections of this manual in more detail.

The ESP-1 is simple and straightforward in its operation. The basic principle of operation is that the signal from an attached detector is input into the computer in the ESP-1 instrument, and this signal is converted to count rate. The ESP-1 can be used either as a rate meter or as a scaler, and a variety of units can be selected for display of the data.

The ESP-1 has three modes of operation:

a. The Rate Meter Mode:

- updates and displays selected units per time, such as counts per minute or mR/h;
- provides the operator with a dual representation of count rate; that is, it provides a moving analog bar graph representing count rate and also a digital value for count rate;
- alarms when a preset value is exceeded.

The Rate Meter Mode is generally used for routine surveys of surfaces, personnel, and clothing for either contamination or exposure rate measurements from a radioactive source.

b. The Scaler Mode:

- allows setting the time interval over which counts or events are to be measured;
- counting is started and ends after the selected time interval;
- registers the number of events for integrated exposure in the selected time interval;
- sounds audible alarm if the integrated counts in the selected time period exceeds the value set on the alarm.

The Scaler Mode is used for quantitive data accumulation over a longer period of time. Using the Scaler Mode, comparisons can be made of radioactivity in various samples or situations with the result that increased accuracy in the data may be obtained by counting over longer periods of time. An example would be the determination of thyroid gland burden of radio iodine by counting the thyroid for a period of time, perhaps five minutes. This mode can be disabled by an internal switch; refer to section II.D.

c. Inquiry/Calibration Mode:

- enables the user to select the units which will be used in the Rate meter Mode;
- enables the user to set the alarm point;
- enables the user to set two constants, the calibration constant (CC) and the dead time (DT) for the particular detector being used;
- enables the user to monitor the high voltage which is applied to the detector.

This mode can be disabled by an internal switch; refer to section II.E.

2. User Calibration

a. User Calibration of the ESP-1 with a detector purchased with the instrument:

The ESP-1 is calibrated at the manufacturing facility. If the instrument was purchased with a detector, the correct calibration factors for that detector are already entered at the factory and the instrument is ready for immediate use. You should verify that these parameters are the same as those supplied on the calibration certificate supplied with the detector. Refer to section II.E. for directions on viewing the parameters.

b. User Calibration of ESP-1 with Various Detectors:

If a radiation detector was not purchased with the ESP-1 from the factory, the ESP-1 was calibrated generically at the factory rather than for a specific detector. In that case, calibration factors for the detector of choice will have to be entered into the ESP-1 before it is ready for use.

CAUTION

Failure to enter the correct parameters for the detector being used may result in erroneous values being presented on the display of the ESP-1.

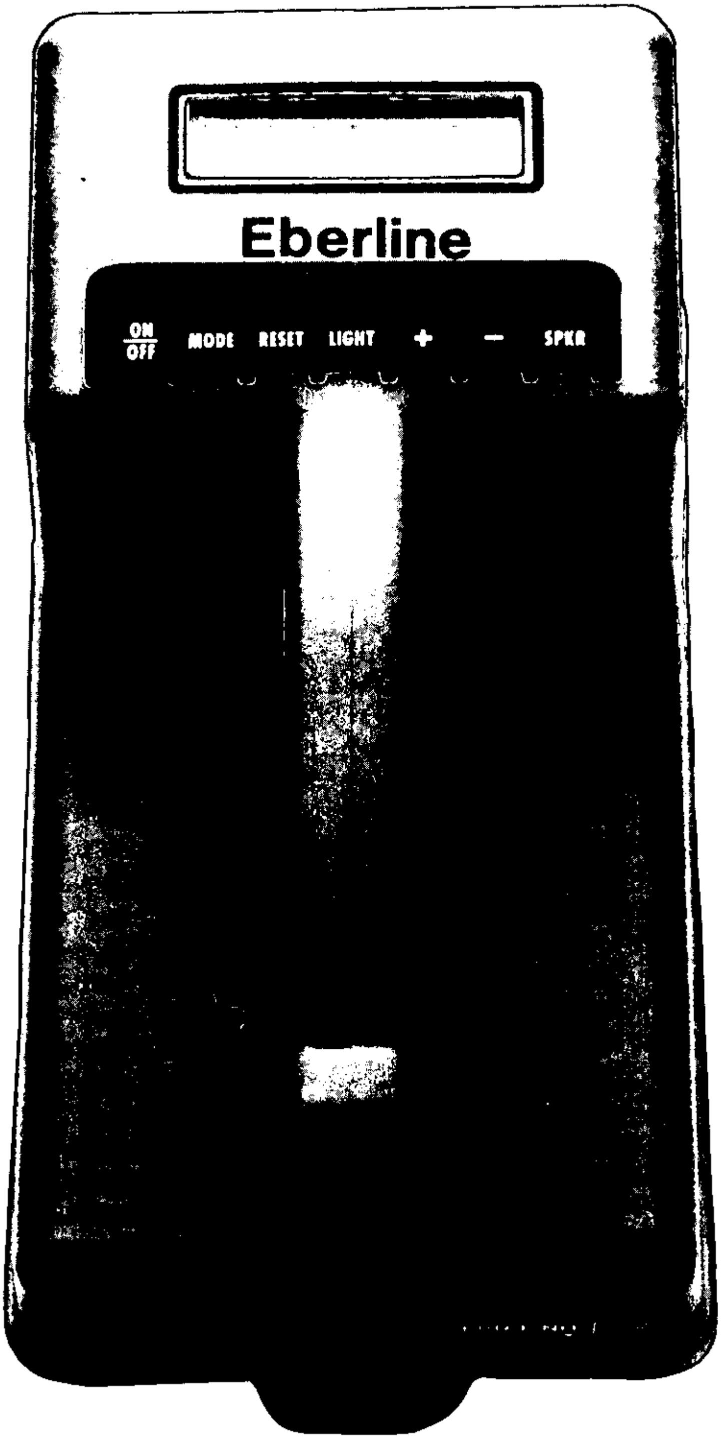


Figure 2-1. External Controls and Display

The parameters which require being set for a particular detector are:

	Section
1) Alarm Point	II.E.1.
2) Units	II.E.2.
3) Calibration Constant	II.E.3.
4) Detector Dead Time	II.E.4.
5) High Voltage	II.E.5.

The last four are preset at the factory for the detector which was purchased with the ESP-1. The alarm point is set at a high value at the factory and, thus, should be reset to a user determined value if it is desired to use this feature of the instrument.

Section II.E. provides simple instructions on how to reset (recalibrate) the items when changing detectors or recalibrating the instrument.

The high voltage should be checked or readjusted for a new detector, PRIOR to connecting the detector. Failure to do so may result in damage to the detector.

3. Calibrations Required by Regulatory Agencies

Regulatory agencies generally require routine laboratory calibration of radiation survey instruments by an approved facility at least once per year. To have your instrument recalibrated return the ESP-1 and detector to the factory in Santa Fe, to the Eberline repair facility in Columbia, South Carolina, or to another approved calibration facility. If your facility has been approved for such calibrations, this may be accomplished by using the procedures given in section V, "Calibration."

B. PRELIMINARY INSTRUCTIONS

Upon receiving the ESP-1 perform the following before proceeding.

1. Set Up the ESP-1 and Detector

The ESP-1 has an MHV connector on its front surface for connection to a radiation detector. This connector supplies high voltage to the detector and also transmits the detector signal to the ESP-1 for processing and display. If the ESP-1 is already connected to a detector then it is reasonable to assume that the high voltage has been previously set. If you are not sure that the high voltage has been properly adjusted, disconnect the detector from the instrument by rotating the cable connector counterclockwise. You can proceed through these instructions without the detector being connected.

CAUTION

> Failure to disconnect the detector from the instrument before turning it on can damage the detector if the high voltage is not set properly for the particular detector. Instructions for checking and setting the high voltage can be found in section II.E.5.

When you are ready to connect the detector, verify that you have the proper cable. It should have a MHV connector on one end which mates to the ESP-1 and a connector on the other end to mate with the detector. Refer to the ESP-1 catalog sheet for the proper cable to use with the specific detector. The cable number is printed somewhere along the length of the cable. The MHV end of the cable connector typically has white insulation in the center which extends slightly beyond the end of the metal portion of the connector. In contrast, a BNC cable connector typically has the insulation flush with the connector end. To connect the cable, rotate the connector clockwise.

2. Turn the Instrument *ON* and *OFF*

Press the *ON/OFF* switch to turn the instrument on. The same switch will have to be pressed to turn the instrument off.

When the instrument is turned on, the display should indicate a numerical value on the lower line and a bar graph on the upper line. The bar graph may be off-scale, so press the *RESET* button to get it back on scale. The ESP-1 is in its Rate Meter Mode. Refer to section II.C. for more information on the displayed information.

If the instrument has been properly calibrated and is connected to a detector, it is ready to use. Refer to section II.E. for instructions on how to view and change the calibration parameters.

A quick check to determine that the instrument is functioning is to compare the numerical value being displayed to the background radiation level. If they are close, then the instrument is operating and ready to use. Remember that normal statistical fluctuations can cause relatively large changes in the displayed reading at low levels. Press the *SPKR* button and you should hear a click corresponding to each detector event. If this is not the case, the speaker rate switch could be in the wrong position. Refer to section III.A.2.

3. Determine Low Battery Condition and Battery Replacement

Examine the first character space in the display (upper left hand corner). If it is blinking, the batteries are low and need replacing. The ESP-1 uses six "C" cell batteries.

The instrument automatically turns itself off two hours after the low battery condition signal is given. The ESP-1 can be turned back on after it turns off, but will turn itself off again after two hours.

To change batteries, remove the large screw in the bottom of the case, and carefully remove the case bottom while being careful not to disconnect the grounding wire which is connected to the bottom of the case. Replace the batteries while being careful to orient the batteries according to the diagram printed on the bottom surface of the compartment which holds the batteries. (See figure 5-2.)

BATTERY CAUTION

> The ESP-1 and the ESP-2 use a small amount of power from the batteries even when turned off. If the instrument is not going to be used for some period of time (say two months or more), we recommend removing the batteries from the instrument. **The instrument parameters will be lost when the batteries are removed!** The calibration parameters will also be lost when the batteries are drained down. If the batteries are left in the unit, they may leak and cause corrosion.

C. OPERATION IN THE RATE METER MODE

The ESP-1 is automatically placed in the Rate Meter Mode when the instrument is turned on. Examine the display. It will show:

1. **Analog Bar Graph** (at the top of the display)

   The length of the moving analog bar graph is proportional to the detector count rate. One purpose of the moving bar graph is to permit more rapid recognition of a sudden increase or decrease in the radiation field being measured as compared to visual recognition from the changing numbers.

   If the bar graph is off scale in either direction, it may be brought back on scale by pressing the *RESET* button. The full scale value of the bar depends on the level of radiation being measured. Pressing the *RESET* button always resets the value of the bar graph to a point that is 33 percent of full scale. If the bar graph is displayed and is varying, the ESP-1 is working.

2. **Numerical Value of Count Rate** (at the bottom of the display)

   The second line of the display is the numerical value of the count rate. The value is expressed as a number followed by a second positive or negative number. The second number corresponds to a power of 10. Example: 1.00 "+" 02 mR/h is $1 \times 10^2 = 100$ mR/h.

3. **Alarm**

   The alarm point is a selected value which results in an audible alarm when the counting rate reaches that value. To silence the alarm, press *SPKR* key. The alarm will sound even if the speaker is off at the time the alarm is activated.

   The alarm point can be viewed and set by pressing the *MODE* key. The display will contain either the "ALM AT" (Alarm Setting) display or will contain the "SCALER MODE?" prompt. If the latter is displayed, press the - key and you will see:

   ALM AT (ALARM SETTING)
   RATE METER READING

   The value of the alarm setting "ALM AT" can be increased or decreased as desired by simultaneously pressing *RESET* and + or *RESET* and -.

Note that the longer the *RESET* and + or - are held down, the faster the value changes. In this manner large changes in value can be made in a relatively short period of time. When the changing value approaches the desired value, release the keys and then press them down again to permit slow changes in the displayed numbers until the desired value is reached.

When the desired value of "ALM AT" is displayed, press the *MODE* key to return to the bar graph display.

CAUTION

While "ALM AT" is being displayed, the instrument will not provide an audible alarm even if the counting rate exceeds the alarm point. The audible alarm is only active in the Rate Meter Mode when the bar graph is displayed (regardless of whether the bar graph is on scale or not).

4. Overrange Indication

When the detector pulse rate exceeds the capability of the ESP-1 to maintain a linear relationship between radiation level and displayed reading, the words "OVERRANGE" will appear on the display in place of the analog bar graph. Numerical value will still be displayed but **should not be relied upon** as the useful range of the ESP-1 and detector has been exceeded. This is a latching condition, and once it occurs, the words "OVERRANGE" will be displayed in all three modes of operation. To clear the condition, the ESP-1 must be turned off and then back on. The overrange determination is based upon the detector pulse rate and the dead time (see section II.E.4.). This feature **requires** that the ESP-1 and detector be properly calibrated for it to function correctly.

D. OPERATION IN SCALER MODE

Start with the instrument in the Rate Meter Mode. Press the *MODE* switch. The display should read:

SCALER MODE
+ = USE/- = NO

If the display does not indicate the above, the Scaler Mode has been disabled by an internal switch. To enable access to this mode, first open the door in the side of the instrument and locate the switch in the lower left corner marked *SCALER*. Refer to figure 3-1. Move this switch to the *ENABLE* position by sliding it to the left.

If the + key is pressed, the Scaler function will be selected. If the - switch is pressed, the instrument will again be placed in the Inquiry/Calibration Mode provided it has not been disabled by the internal switch. Press the + key. The display will read:

UNITS = EVENTS
+ = USE/- = NO

or

UNITS = (UNITS SELECTED)
+ = USE/- = NO

CAUTION

> When using the scaler mode the dead time correction is **always** disabled. The calibration constant, however, is applied **except** when the units selected are "events". To repeat: When in the scaler mode, the units selected must be "events" or a calibration constant will be applied to the output.

Units are either events or the selected rate meter units (e.g., mR, rem, CNT). To select units, press - until the desired unit is displayed. Then press + to accept the unit displayed. The display will change to:

UNITS = (AS SELECTED)
ALM AT (ALARM SETTING)

The alarm indicated here is **not** the rate meter alarm, but is one that sounds if the set value of total (integrated) events or selected units is exceeded. Pressing *RESET* and + or - simultaneously will increase or decrease the total at which the alarm sounds. Press +. The display will read:

UNITS = (AS SELECTED)
CNT FOR (COUNT PERIOD)

The count period can be set by the operator for any interval from 1 second to 4 hours. Pressing *RESET* and + or - simultaneously will increase or decrease the length of the counting period.

To obtain a total count over a set count period, press +. The display will read:

CNT FOR (X:XX:XX)(h:m:s)
RESET TO START

Press *RESET*. After one second, the display will read:

(X:XX:XX) LEFT (h:m:s)
(TOTAL COUNT SO FAR)

When the count period has expired, the display will read:

CNT FOR (X:XX:XX)
(TOTAL COUNT)

For another total count, pressing *RESET* erases the previous count and starts a new counting interval. During the count period, the audio alarm will sound if the alarm limit is exceeded.

When operations or settings in the Scaler Mode have been completed, pressing *MODE* twice will shift the ESP-1 to the rate meter mode. The display will read:

llll (BAR GRAPH)
RATE METER READING

E. OPERATION IN INQUIRY/CALIBRATION MODE

1. Selecting of Inquiry/Calibration Mode and Setting the Alarm

After turning on the instrument it will be in the rate meter mode. Press the *MODE* key and the display will read:

SCALER MODE
+ = USE/- = NO

or

ALM AT (ALARM SETTING)
RATE METER READING

If the "SCALER MODE" prompt is displayed (the first possibility shown above) then press the - key to enter the Inquiry/Calibration Mode and obtain the "ALM AT" display (the second possible display shown above). Pressing the + key will place the instrument in the Scaler Mode; refer to section II.D.

The first entry in this mode is the alarm point viewing and setting. Refer to section II.C.3. where directions for this procedure have already been given in the discussion on the rate meter mode. When the desired value of "ALM AT" is displayed, press the + key.

2. Changing Units

a. When the + key is pressed (step 1), the display should show:

UNITS = (UNITS SELECTED)
RATE METER READING

If the display does not indicate the above, the Inquiry/Calibration Mode has been disabled by an internal switch. To enable access to this mode, first open the door in the side of the instrument and locate the switch in the lower left corner marked *INQUIRY/CALIBRATION*. Refer to figure 3-1. Move this switch to the *ENABLE* position by sliding it to the left. This will permit adjusting of all the parameters that can be changed from the keypad on the top of the instrument. Likewise, after all the parameters have been adjusted, placing the switch in the *DISABLE* position will prevent changing of the parameters from the top of the instrument.

b. If the units currently displayed are acceptable, the next step (c.) may be bypassed by pressing +.

c. If units other than those displayed are desired, press *RESET*. The options for selection are the "BASE" unit, the "SUFFIX" on the unit, and the "PREFIX" on the unit. The first display will be the selection of the base unit as follows:

BASE (UNIT)
+ = USE/- = NO

The selection of the "BASE" units is now possible.

The choices available for base radiation units are:

R	roentgen
cnt	counts
Gy	gray
Sv	sieverts
rem	roentgen equivalent man
dis	disintegrations
rad	rad

Notice that the base unit is what is displayed; thus, if mR/h is desired on the display, select "R" as the base unit. The prefix (milli) and the suffix (h) will be added in the next steps.

In each case, press - to reject the displayed parameter, and another selection will be offered. When the display shows the desired base unit, press + to accept it.

CAUTION

Selection of a new base unit requires an appropriate change in the calibration constant (CC). Refer to section II.E.3. Changing the prefix or suffix **does not** affect calibration and so requires no change in the calibration constant.

Selection of "SUFFIX"

After the + is pressed (as discussed above) to accept the base unit, the display will then present the selection of suffix as follows:

SUFFIX (UNIT TIME)
+ = USE/- = NO

The suffix is the unit of time used to calculate the displayed "RATE METER READING." Three are available:

s	second
min	minute
h	hour

Again, press the - switch to reject the suffix displayed and call the next choice to be displayed. When the desired suffix is displayed, press + to accept it.

Selection of "PREFIX"

After the + is pressed above to accept the suffix, the display will then present the selection of prefix as follows:

PREFIX (VALUE)
+ = USE/- = NO

The prefix is the value by which the base unit is multiplied to provide a more convenient unit of actual measurement. Four are available:

(NONE)	no prefix
μ	micro (x 10^{-6})
m	milli (x 10^{-3})
k	kilo (x 10^{+3})

If the prefix displayed is not the desired value, then press - to reject it and call the next choice to be displayed. When the desired prefix is displayed, press + to select it. The setting of radiation units to be measured would now be complete. An example of this would be:

PREFIX	BASE	SUFFIX
m	R	/ h
(milli)	(roentgen)	/ (hour)

The units may be selected in any combination of prefix/base/suffix. Press the + switch to select the prefix.

3. Setting the Calibration Constant (CC)

a. Definition of Calibration Constant:

The calibration constant (CC) is the number used to convert the counts from the detector to the previously displayed base unit. Specifically, the displayed rate meter reading is derived by dividing the counts per seconds (from the detector) by CC and then scaling the result based on the selected prefix and suffix.

b. Display of Calibration Constant (CC) Setting:

If the current value for the units was accepted by pressing + (step 2 above), the display will read:

CC = (NUMERICAL VALUE)
RATE METER READING

c. Selection of "CC" for detectors which were purchased with the ESP-1 from the factory:

If a detector was purchased with the ESP-1 from the factory, the calibration constant will already be set at the factory for this detector and the following section may be bypassed until a different type of detector is to be used with the instrument, or until time for routine recalibration of the instrument.

The calibration constant will have to be changed when switching detectors. When changing back from another detector to the detector which was purchased with the ESP-1, use the calibration constant which is given on the calibration sheet supplied with the combined ESP-1 and detector. Change values by pressing simultaneously either *RESET* and + or *RESET* and -.

d. Selection of Calibration Constant for various detectors:

(1) If the detector was not purchased with the ESP-1 and, thus, a calibration sheet is not available, use the nominal value for the particular Eberline detector which is given in section V, "Maintenance," 11292-A36.

(2) To increase the value of CC, press *RESET* and + simultaneously. To decrease the value of CC, press *RESET* and - simultaneously.

(3) To calculate a calibration constant for detectors other than those listed in the table, the sensitivity of the detector must be known and is usually found in the list of specifications given on the catalog sheet. Calculations using a HP-270 detector as an example are given as follows:

sensitivity = 1200 c/min/mR/h

Calibration =

$$\frac{1200 \text{ c/min}}{\text{mR/h}} \times 1000 \text{ mR/R} \times 60 \text{ min/h} = 7.20 + 07 \text{ c/R}$$

4. Setting the Dead Time (DT)

a. Definition:

The dead-time correction constant is a derived number used to correct for counting losses due to inability of the detector to recover at high counting rates. This correction results in a more linear response to the radiation field being measured and extends the useful range of some detectors used with the ESP-1 by a factor of as much as ten times (which provides the equivalent of an extra range on a standard rate meter).

b. Selection of "DT" for detectors which were purchased from the factory with the instrument:

If the ESP-1 was purchased with a detector from the factory, the DT value will be correctly set at the factory and the next section may be bypassed until it is necessary to use a different detector or until time for routine calibration.

When changing back from another detector to the detector purchased with the ESP-1, use the DT given on the calibration sheet supplied with the combined ESP-1 and detector.

c. Selection of DT for Various Detectors:

(1) If the detector was not purchased with the ESP-1 and, thus, a combined calibration data sheet is not available, use the nominal value for the particular detector which is given in Section V, "Maintenance," 11292-A36.

(2) To increase the value of DT, simultaneously press *RESET* and +. To decrease the value of DT, simultaneously press *RESET* and -.

(3) For a detailed discussion of DT consult section V.A., "Calibration".

CAUTION

If you do change detectors, the calibration constant (CC) and the dead time (DT) must be changed. Use the procedures just described in section II.E., steps 3 and 4.

5. Setting the High Voltage for the Detector of Choice

CAUTION

Do not press any of the keys! The high voltage is **not** changed from the top of the instrument. Proceed as follows:

a. Selection of High Voltage for detectors which were purchased from the factory with the instrument:

If a detector was purchased from the factory with the instrument, the operating high voltage will already be set at the factory for this detector, and the following section may be bypassed until a different type of detector is to be used with the instrument.

b. Selection of High Voltage of Various Detectors:

(1) If the calibration data sheet supplied with the detector is available, use the recommended operating high voltage which is given there.

(2) If the calibration sheet supplied with the detector is **not** available, use the following general recommendations:

(a) Geiger-type detectors (HP-190, HP-260, HP-270): use 900 volts (exception: HP-290 requires 550 volts).

(b) Scintillation and proportional detectors: determine the plateau response of the detector according to the procedure described in section V.A.3.c. and figure 5-1, and select an operating voltage value which is 75 volts above the beginning of the plateau.

c. Procedure for Determining the Present Setting for the High Voltage as Viewed on the Display:

After the desired value for DT is selected (as discussed above), press +. The display will then show the present value for the high voltage setting and will look like this:

HV = (NUMERICAL VALUE)
RATEMETER READING

If this value is not the recommended high voltage for the detector which you plan to use with the instrument, change the value using the directions given in step d. (following).

CAUTION

> Do not attempt to adjust the high voltage using the keys on top of the instrument. This adjustment is accomplished by an internal potentiometer.

d. Changing the High Voltage:

(1) Disconnect the detector from the instrument by rotating the MHV connector counterclockwise and then open the door on the side of the instrument.

(2) Refer to figure 3-1. Using a small screwdriver, adjust the potentiometer marked HV (the third potentiometer from the right) until the value seen on the display is the value desired for the operating high voltage.

The operating high voltage must be changed when switching to a different type of detector, such as switching from Geiger-Mueller (G-M or ionization) type of detector (HP210, HP-260, HP-190, HP-270, HP-290) to a scintillation type detector (LEG-1, SPA-3, SPA-6, etc.) or to the neutron detector (NRD-1). To accomplish this, remember that **high voltage can only be changed with a screwdriver at the side of the instrument** (inside the compartment at the right side) by adjusting the correct potentiometer (Figure 3-1) and viewing the values on the display until the desired voltage is reached. **Do not attempt to change the values shown on the display for "HV" by pressing *RESET* and + or -.** This would change the calibration of the display itself; it does **not** change the high voltage. If this occurs, the instrument will have to be recalibrated by returning the instrument to the factory for recalibration. It is possible to operate the detector at the wrong high voltage and not realize it. This may result in damage to the detector or may result in erroneous values being presented on the display of the ESP-1.

Make sure that you check the high voltage when changing from a scintillation detector to a Geiger-type detector, **before** you attach the detector to the ESP-1. This will protect your Geiger detectors from accidental exposure to voltage which is too high for the tube.

(3) The detector of choice may now be attached to the ESP-1 since there is now assurance that the correct high voltage will be applied by the instrument to the detector.

The next sequence on the display (after the "HV" display) goes back to the beginning of the sequence, which is the "ALM AT" parameter. Return to the Rate Meter Mode by pressing the MODE key.

F. SIMPLE TROUBLESHOOTING

Although detailed troubleshooting will be given in section V, two simple suggestions for troubleshooting will be given here.

1. **Condition:** Blinking character or letter on the display.

   If the character in the upper left-hand corner of the display is blinking, the batteries are low and need replacing.

   Remove the large screw in the bottom of the case, and carefully remove the case bottom while being careful not to disconnect the grounding wire which is connected to the bottom of the case. Replace the batteries while being careful to orient the batteries according to the diagram printed on the bottom surface of the compartment which holds the batteries. See figure 5-2.

2. **Condition:** Display prints erratic numbers or figures ("garbage").

   If the display shows characters or letters which are not a part of the usual display mode (displays "garbage"), the program in the microprocessor has lost its initialization (has become "scrambled"). To correct this condition and reinitialize the microprocessor, perform one of the following procedures:

   a. Take the batteries out of the instrument and wait at least 30 minutes. This will give adequate time for a capacitor (C1) to discharge and allow the microprocessor to reinitialize itself when the batteries are replaced and the instrument turned on.

   b. **Or**, if you cannot wait 30 minutes: **After removing the batteries**, perform the following steps:

      (1) Remove the side door to the instrument.

      (2) Refer to figure 3-1. Look inside the instrument and locate capacitor C1. This capacitor is located on the top electronic board(in the top half of the area which is visible after the side door is removed). It is round in shape and is 5/8 inch in height and 5/8 inch in diameter and it is usually green or gray in color.

      (3) Discharge this capacitor by touching the end of a small screwdriver across the two leads of the capacitor. A small discharge noise may be heard. Hold the short for 30 seconds.

   c. Replace the batteries in the instrument, while being careful to orient them according to the diagram printed on the bottom surface of the compartment which holds the batteries.

   d. Turn on the instrument and determine if the condition is corrected. The display should present letters and numbers which are a part of the usual display modes and are "reasonable."

e. If the display is still not functioning correctly, you may wish to consult detailed troubleshooting in section V or return your instrument to the factory for repair.

CAUTION

> Reinitializing the microprocessor resets all parameters, including the high-voltage calibration. **Complete** recalibration must be performed before using the instrument.

SECTION 3

SECTION III. DETAILED OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. Operator Controls - External (figure 2-1)

a. *ON/OFF*: Pressing this switch turns the instrument on or off.

b. *MODE*: Pressing the *MODE* switch changes the mode from that currently selected to one of the other modes (Rate Meter, Scaler, or Inquiry/Calibration.)

c. *RESET*: The functions of the *RESET* switch depend on the operating mode selected for the instrument.

(1) In the Rate Meter Mode the *RESET* switch is used to maintain the bar graph on the display.

(2) In the Scaler Mode the *RESET* switch resets the ESP-1 to a new count interval and starts the count. When used simultaneously with "+" or "-", pressing the *RESET* will increase or decrease the selected parameter (count interval or alarm set point).

(3) In the Inquiry/Calibration Mode the *RESET* switch has two functions. Used alone, when units are displayed on the first line, it allows the operator to select or to change to another unit. When the operator is examining or setting parameters (calibration constant, dead time, or alarm), *RESET* used simultaneously with "+" or "-" will increase or decrease the value set for that parameter.

d. *LIGHT*: When the *LIGHT* switch is pressed, the display is illuminated.

e. +: The functions of the "+" switch depend on the operating mode.

(1) In Rate Meter Mode: The ESP-1 automatically varies response time with count rate to maintain a maximum ±5 percent standard deviation above 2500 cpm. The normal (fast) response time ranges between 1.0 and 10.0 seconds. A slower response time, ranging from 1.8 to 29.0 seconds is available to maintain a maximum ±3 percent standard deviation above 2500 cpm. The improved accuracy/slow response time is operative while the "+" switch is pressed and for one minute after it is released.

(2) In Scaler Mode: The "+" switch is used to set up the instrument to count events or basic units over a selected time interval. When used simultaneously with *RESET*, it increases the count interval or alarm set point.

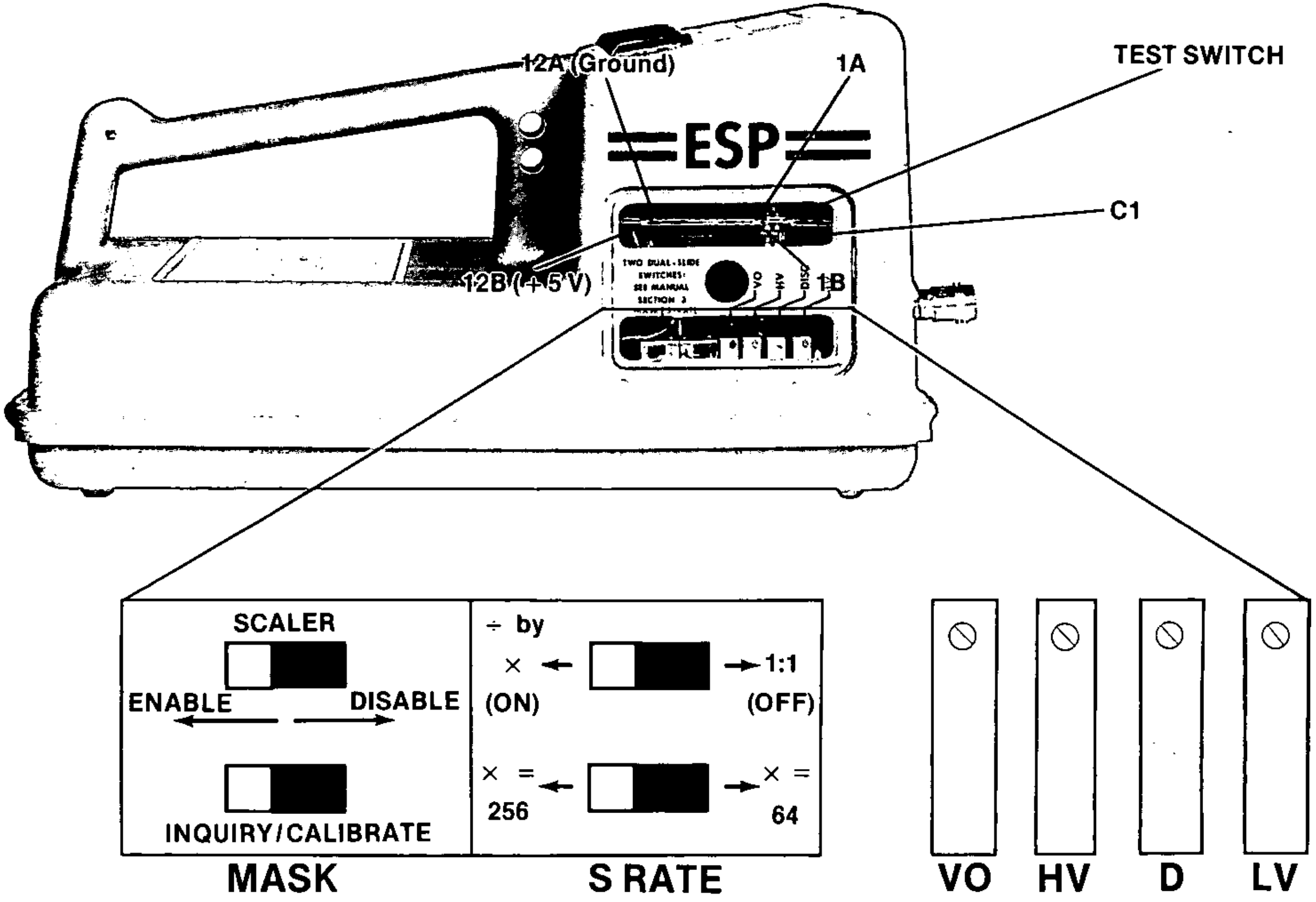


Figure 3-1. Internal Controls

NOTE:Mask and Speaker Rate (S Rate) switches are comprised of a pair of switches located one above the other. The lower switches are hidden from view by the case of the instrument. They can easily be set by first moving the upper switch actuator out of the way, positioning the lower switch to the desired position with a small object, such as a mechanical pencil, then repositioning the upper switch.

(3) In Inquiry/Calibration Mode: The + switch has two functions. Used alone, it causes display of the next parameter in the list of parameters. Used simultaneously with *RESET*, it allows the operator to increase the value of the selected parameter.

CAUTION

External keypad controls allow monitoring and calibration of the high voltage display, but do not allow setting (or changing) the actual high voltage. Do not attempt to change the high voltage by pressing *RESET* + or *RESET* -. Refer to the "Operator Controls" section for a description of the internal potentiometer used to vary the actual high voltage.

f. -: The functions of the "-" switch depend on the operating mode.

(1) In Rate Meter Mode: If the slow response time is being used, pressing the - switch will override the one minute delay and will immediately place the ESP-1 back in the fast response time.

(2) In Scaler Mode: The "-" switch is used to provide the operator access to the list of parameters. When used simultaneously with *RESET*, "-" decreases the count interval or alarm set point.

(3) In Inquiry/Calibration Mode: The - switch has two functions. Used alone, it causes display of the preceding parameter in the list of parameters. Used simultaneously with *RESET*, it allows the operator to decrease the value of the selected parameter.

g. *SPKR*: Pressing the *SPKR* switch turns the speaker on or off. It also turns off the alarm when it sounds. When *SPKR* is used to silence the alarm, the speaker remains on until the operator presses *SPKR* again.

2. Operator Controls - Internal (figure 3-1)

Removing the right side door will provide access to the following:

a. *LV*: This potentiometer adjusts the operating voltage for the instrument. It is set for 5.00V.

b. *D*: This potentiometer is the discriminator adjustment. It is set to an optimum input sensitivity for the detector being used. (See section V.)

c. *HV*: This potentiometer adjusts the high voltage (detector bias). It is set to the optimum operating voltage for the detector being used (see section V). High voltage is continuously variable from 350 to 2300 V. Turn the potentiometer clockwise to increase the high voltage and counterclockwise to decrease it. The value of the high voltage being output to the detector is displayed as the "HV=" parameter in the Inquiry/Calibration Mode.

d. *VO*: This potentiometer adjusts the viewing angle of the display. It is set by the operator to optimize the readout to his manner of using the instrument.

e. *S RATE* (one switch, three positions): These switch positions select the rate heard from the speaker. They are used to scale down the count rate from a high count rate detector (e.g.;

SPA-3) to a more usable rate from the speaker. The operator can set the rate heard from the speaker to be equal to the detector count rate or equal to the detector count rate divided by either 64 or 256. Figure 3-1 explains the switch settings.

f. *MASK* (two SPST switches): One switch disables the Scaler Mode. The other disables the Inquiry/Calibration Mode except for the Rate Meter "alarm setting." Either function or both may be disabled. Figure 3-1 explains the switches.

g. *TEST*: This switch is for use with automatic testing only and should always be set in the operate position (both poles up, toward PC board).

B. PREPARATION FOR USE AND OPERATIONAL CHECK

1. The instrument should be provided to the operator already calibrated and with the proper probe attached (section VIII).

2. The instrument should be checked for physical damage.

3. Insure that the instrument is operating by pressing the *ON/OFF* switch, energizing the instrument and causing the LCD readout to show the bar graph on the first line and a numerical value of count rate on the second line. If the first character of the display is steady, battery output is adequate. If the first character of the display is blinking, the operator should consider replacing the batteries before proceeding.

4. Press *RESET*. If the bar graph is displayed and is varying, the ESP-1 is working. Exposure to a radiation check source will confirm proper operation by causing the bar graph level and the digital value to increase.

5. Press and hold down the *LIGHT* switch. The display should be illuminated. If the outside light is too bright, shield the display so that the instrument light can be seen. Release the *LIGHT* switch.

6. Press the *SPKR* switch and listen for an audio indication that the instrument is detecting "events." This indication is a series of "click" sounds from the speaker. The presence of this indication confirms that the ESP-1 is operating, although its absence does not confirm that the instrument is not operating.

C. OPERATING THE INSTRUMENT

The ESP-1 is simple and straight forward in its operation. Turn the ESP-1 on by pressing the *ON/OFF* switch to obtain a display on the LCD.

1. Rate Meter Mode (refer to figure 3-2)

The instrument is always in Rate Meter Mode when it is first turned on. The display will read:

IIIIIIIII [BAR GRAPH]
RATEMETER READING

Press *MODE*. If Scaler and Inquiry/Calibration Modes are disabled the display will look like:

ALM [ALARM SETTING]
RATEMETER READING

The setting of "ALM AT" establishes the count rate at which the alarm sounds. If the level of activity exceeds this setting, the operator will be alerted by a 2000-Hz tone emitted by the speaker. This tone will sound even if the speaker is off at the time the alarm is activated. Pressing *SPKR* acknowledges the alarm, silencing it. The alarm will remain silent until the readout has dropped below the alarm setting and exceeded it again. The value of the alarm setting can be increased or decreased by pressing *RESET* and "+" or "-" simultaneously. When the desired value of "ALM AT" is displayed, press *MODE* to return to Rate Meter Mode.

NOTE

> The longer *RESET* and "+" or "-" are depressed, the faster the value changes. This facilitates large value changes in a relatively short time. Releasing the switches and depressing again will return to slower value changes. This applies anytime *RESET* and "+" or "-" are used as described in the operations that follow.

When the ESP-1 is in the Rate Meter Mode, the operator may adjust the full scale of the bar graph and choose fast or slow ranges of response time.

The bar graph functions essentially as a graphic presentation of detector count rate. Pressing *RESET* will position the end of the bar graph at a point that is 33 percent of the total window width from the left side of the display. As an example, 100 mR/h is displayed as:

lllllll
1.00 + 02 mR/h

When *RESET* is pressed, the end of the bar graph represents 100 mR/h. If the level drops, the end of the bar graph will move to the left. If the level increases, the end of the bar graph will move to the right. If the level increases more than a factor of 3 (above 300 mR/h in this example), the end of the bar graph will go off scale on the right. Pressing *RESET* will bring the end of the bar graph into view again and will set its value again.

2. **Scaler Mode** (refer to figure 3-3)

Begin in Rate Meter Mode and press *MODE*. If the Inquiry/Calibration Mode is disabled, the display will read:

SCALER MODE?
+ = USE/- = NO

Pressing "-" will call the "ALM AT" parameter as previously described. Press "+." You are now in the Scaler Mode. The display will read:

UNITS = EVENTS
+ = USE/- = NO

or

UNITS = [UNITS SELECTED]
+ = USE/- = NO

CAUTION

When using the scaler mode, the dead time correction is always disabled. The calibration constant, however, is applied except when the units selected are "events". To repeat: when in the scaler mode, the units selected must be "events" or a calibration constant will be applied to the output.

"UNITS" are either events or the selected rate meter units (e.g., mR, REM, CNT). To select "UNITS," press "-" until the desired unit is displayed. Then press "+" to accept the unit displayed. The display will change to:

UNITS = [AS SELECTED]
ALM AT [ALARM SETTING]

The alarm indicated here is not the rate meter alarm, but is one that sounds if the set value of total (integrated) events or selected units is exceeded. Pressing *RESET* and "+" or "-" simultaneously will increase or decrease the total at which the alarm sounds. Press "+." The display will read:

UNITS = [AS SELECTED]
CNT FOR [COUNT PERIOD]

The "COUNT PERIOD" can be set by the operator for any interval from 1 second to 4 hours. Pressing *RESET* and "+" or "-" simultaneously will increase or decrease the length of the counting period.

To obtain a total count over a set count period, press "+." The display will read:

CNT FOR (X:XX:XX)(h:m:s)
"RESET" TO START

Press *RESET*. After one second, the display will read:

[X:XX:XX] LEFT (h:m:s)
[TOTAL COUNT SO FAR]

When the count period has expired, the display will read:

CNT FOR (X:XX:XX)
[TOTAL COUNT]

For another total count, pressing *RESET* erases the previous count and starts a new counting interval. During the count period, the audio alarm will sound if the alarm limit is exceeded.

When operations or settings in the Scaler Mode have been completed, pressing *MODE* twice will shift the ESP-1 to the Rate Meter Mode. The display will read:

lllll [BAR GRAPH]
RATE METER READING

3. **Inquiry/Calibration Mode** (all modes enabled, refer to figure 3-4).

Begin in the Rate Meter Mode. Press the *MODE* switch. The display will read:

SCALER MODE?
+ = USE/- = NO

Pressing - will place the instrument in the Inquiry/Calibration Mode. The display will read:

ALM AT [ALARM SETTING]
RATE METER READING

The value of alarm setting, "ALM AT," can be increased or decreased as desired, by pressing *RESET* and "+" or "-" simultaneously. This value of alarm setting is in the same units as shown on the bottom line of the display, (e.g. mR/h, REM/h,CNT/min). When the desired value of "ALM AT" is displayed, press "+." The display will read:

UNITS = [UNITS SELECTED]
+ = USE/- = NO

If the units displayed are acceptable, press "+" to go on to setting parameters (CC). If the operator desires units other than those on the display, press *RESET*. The display will read:

BASE [UNIT]
+ = USE/- = NO

The selection of the "BASE" units is now possible. Press the "-" switch to reject the unit displayed and call for the next choice of units to be displayed. The available radiation units are:

R	roentgen
cnt	counts
Gy	gray
Sv	sieverts
rem	roentgen equivalent man
dis	disintegrations
rad	rad

When the display shows the desired base unit, press "+" to accept it. The display will read:

SUFFIX [unit time]
+ = USE/- = NO

The "SUFFIX" is the unit of time over which the base units are counted. Three are available:

s	second
min	minute
h	hour

Press the "-" switch to reject the suffix displayed and call the next choice to be displayed. When the desired suffix is displayed, press "+" to accept it. The display will read:

PREFIX [value]
+ = USE/- = NO

The "PREFIX" is the value by which the base unit is multiplied to provide a more convenient unit of actual measurement. Four are available:

(NONE)	no prefix
µ	micro (x 10^{-6})
m	milli (x 10^{-3})
k	kilo (x 10^{+3})

If the prefix displayed is not the desired value, then press "-" to reject it and call the next choice to be displayed. When the desired prefix is displayed, press "+" to select it. The setting of radiation units to be measured would now be complete. An example of this would be:

PREFIX	BASE	SUFFIX
m	R /	h
(milli)	(roentgen) /	(hour)

The units may be selected in any combination of prefix/base/suffix. Press the "+" switch to select the prefix and prepare the instrument for the setting of parameters, (i.e. calibration). Section V, "Maintenance," provides nominal values of the following parameters as they apply to the particular detector being used. The display will read:

CC = [numerical value]
RATE METER READING

The calibration constant (CC) is the number used to convert the detector count rate to the displayed base unit previously selected. Specifically, the displayed rate meter reading is arrived at by dividing the counts per second (from the detector) by CC and then scaling the result based on the selected prefix and suffix. To increase the value of CC, press *RESET* and "+" simultaneously. To decrease the value of CC press *RESET* and "-" simultaneously. Keep in mind that increasing or decreasing CC will have the inverse affect on the rate meter reading. With the rate meter reading always displayed on the bottom line, the changing value of CC and its effect on the reading is immediately noticeable. When the desired value of CC is displayed, press "+." The display will read:

DT (SEC) [numerical value]
RATE METER READING

This parameter is the dead time (DT) of the detector, in seconds. It is used to correct for coincidence loss from the detector, yielding a more linear response to the radiation field being measured. An extra decade of range is possible from most detectors due to the DT correction. Typical values of DT are in microseconds (x 10^{-6}). To increase the value of DT, press RESET and "+" simultaneously. To decrease the value of DT, press *RESET* and "-" simultaneously.

NOTE

For a more detailed explanation on setting "CC" and "DT," as well as nominal values for various detectors, refer to section V.A.

When the desired value of DT is displayed, press "+." The display will read:

HV = [numerical value]
RATE METER READING

The "HV" value is the high voltage bias applied to the detector. Adjusting the actual high voltage is performed with the **internal** control potentiometer (labeled "HV"). The external controls, *RESET* and "+" or "-," are to be used **only** when calibrating the displayed HV readout to match the actual high voltage (refer to section V). When properly calibrated, the HV parameter allows for high voltage monitoring on the top line of the display and the rate meter reading on the bottom. This is particularly useful when running detector plateaus. Pressing "+" will return the display to the "ALM AT" parameter. Pressing "-" repeatedly will step the instrument through the parameters in reverse order from that shown in the preceding paragraphs. Pressing the *MODE* switch anytime a parameter and a rate meter reading are displayed will revert the instrument to the Rate Meter Mode.

Summarizing, the ESP-1 provides the following to the operator.

a. In the Rate Meter Mode:

- Bar graph graphically displaying count rate.
- Count rate in selected units per unit time.
- Audible alarm if the rate exceeds the value set.

b. In Scaler Mode:

- Time remaining in the counting period which was set.
- Integrated value and selected units so far in the counting period.
- End of counting period, total time, and integrated value in selected units at the end of the counting period.
- Audible alarm if set limit on total count is exceeded during the set count period.

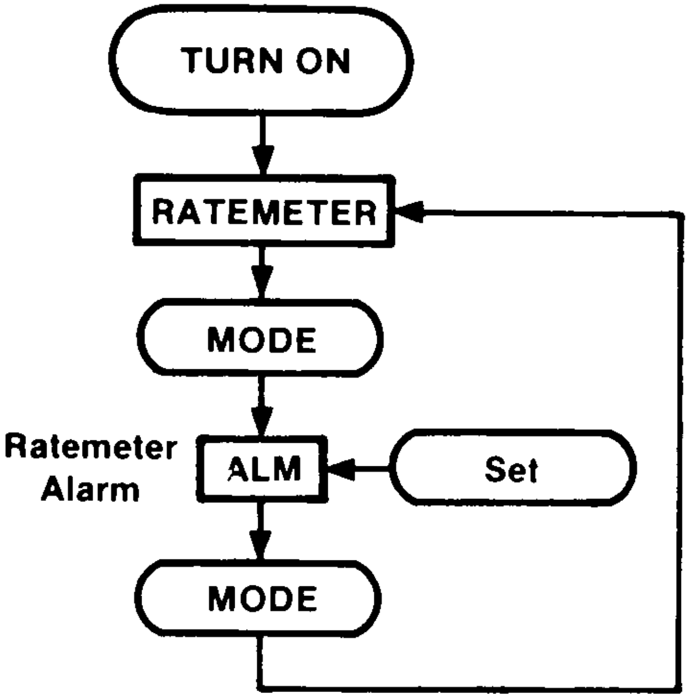
c. In the Inquiry/Calibration Mode

- Ability to set the rate meter alarm point.
- Enables the selection of units to be used in Rate Meter Mode.
- Ability to set the CC and DT (calibrate) to the detector being used.
- Monitor the high voltage applied to the detector. Set the high voltage readout to match the actual HV.

The current rate meter reading is displayed on the bottom line whenever the "ALM AT," "UNITS =," "CC =," "DT," or "HV =" parameters are displayed on the top line.

Block Diagram of ESP-1 Operation
(Scaler and Inquiry/Calibration Modes Disabled)

Rate Meter Mode Operating



NOTES FOR BLOCK DIAGRAMS

1. ○ or ⬭ = Control operation
2. (set) = Increase or decrease value
3. ▭ = Representative display

Figure 3-2. Rate Meter Mode

Block Diagram of ESP-1 Operation

(Inquiry/Calibration Mode Disabled)

Scaler Mode Operating

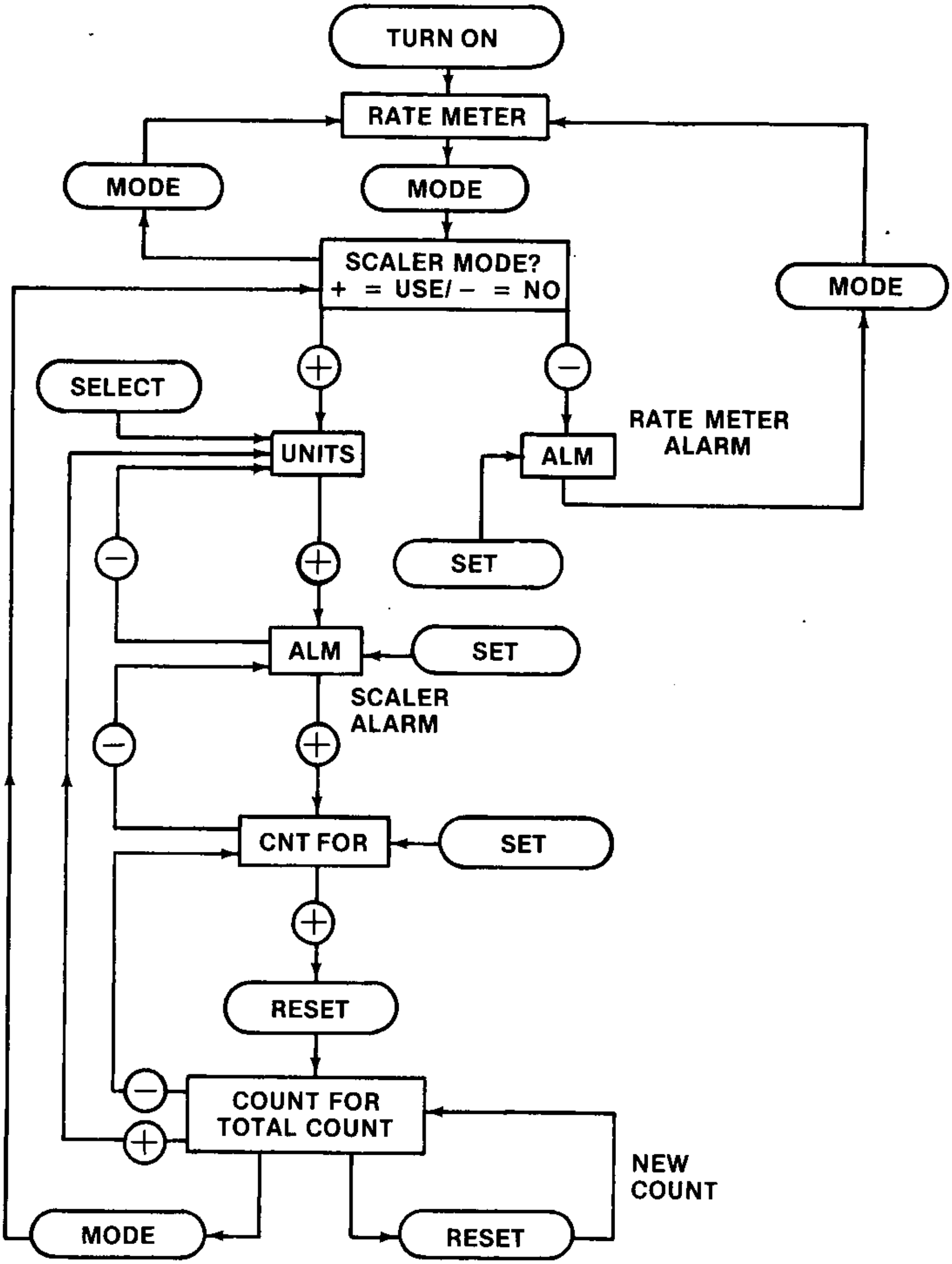


Figure 3-3. Scaler Mode

Block Diagram of ESP-1 Operation

Inquiry/Calibration Mode

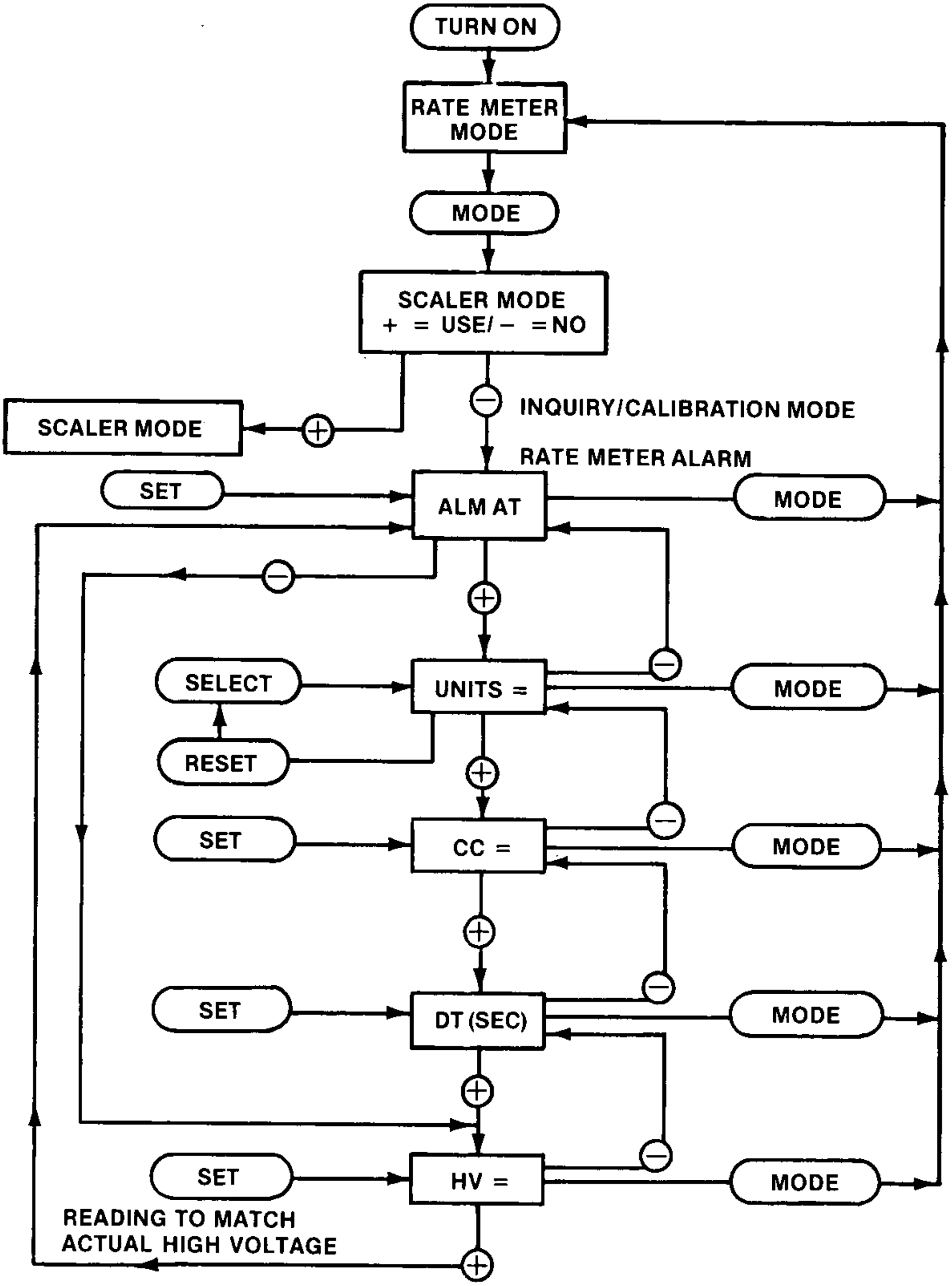


Figure 3-4. Inquiry/Calibration Mode

SECTION 4

SECTION IV. THEORY OF OPERATION

A. GENERAL

The ESP-1 employs current technology to provide to the user a compact instrument that can be used to measure several kinds of radiation as detected by different detectors. In addition, the ESP-1 is portable and will operate for over 250 hours before battery replacement becomes necessary. The instrument's most important function is the delivery of accurate information to the operator efficiently and rapidly.

B. FUNCTIONAL THEORY

The ESP-1 consists of six functional sections as detailed below (see figures 7-1, 7-2, 7-3).

1. Detector

The detector connected to the ESP-1 is selected to optimize its output for the radiation of interest. It provides the pulse signal to the electronics for counting. The pulse rate from the detector is proportional to the radiation-field intensity at the detector.

2. High-Voltage Supply

The high-voltage supply provides the bias voltage to the detector as required for proper operation. The high voltage is adjustable to provide the correct operating voltages for a large selection of detectors and regulated to enhance operating stability.

3. Amplifier/Discriminator

The amplifier is a linear, fixed-gain, multistage design. It amplifies the signal from the probe to a usable level at the amplifier output. The discriminator provides a signal on its output only if the signal from the amplifier exceeds its adjustable threshold. This, in turn, provides a means for counting only the radiation signals and to reject any noise and/or unwanted signals.

4. Speaker/Alarm

The speaker/alarm section provides an audible "click rate" from the speaker, which is proportional to the output of the amplifier/discriminator. This rate can be scaled down to enhance the usefulness of the speaker when high-count rate (very sensitive) detectors are employed. When the alarm is activated, the speaker emits a continuous 2000-Hz tone.

5. Microcomputer

The microcomputer is an eight-bit device programmed to function as the interface between the ESP-1 operator and the information provided by the radiation detector (probe). Its program logic and speed of execution allow the ESP-1 to be extremely versatile by applying mathematical functions and logic to its input signals and displaying the results to the operator in an understandable format.

6. Low-Voltage Supply

The low-voltage supply regulates and provides the control point for the operating voltage for the ESP-1 electronics.

C. OPERATIONAL THEORY

For the discussion that follows, please refer to Figures 7-1 through 7-12.

1. Low-Voltage Power Supply

Power is supplied to the ESP-1 electronics by six C-type batteries and regulated to 5.0 volts with A101. The battery output limits are 9 volts for new batteries down to approximately 5.6 volts for "dead" batteries. The lower limit is set by the voltage differential between the input and output of A101 and enables A101 to maintain voltage regulation.

Computer voltage (Vc) is always applied to the computer to maintain its random-access memory (RAM). With the ESP-1 off, battery drain consists of the normal leakage current of CMOS, typically less than 50 microamperes. During a battery change, capacitor C1 (0.047 F) provides power for RAM for about 20 minutes (instrument off). This power maintains all the operating parameters at the values entered during calibration.

Pressing the *ON/OFF* keypad causes the microcomputer to initialize the program at BEGIN (figure 7-8).

If the ESP-1 is operating when the keypad is pressed, it sets "PWR ON" to A1, HI (+5 V), turning off the low voltage (Q101, Q102, Q103) to all electronics except the microcomputer and its program access (A1, A2, A3).

If the ESP-1 is off when the *ON/OFF* keypad is pressed, it sets "PWR ON" low (0.0 volts) turning Q101 on. This supplies the operating voltage (+V) to the amplifier, high-voltage control, display, and speaker circuitry. It also switches on the battery voltage (V_{BB}) to the HV oscillator and battery sense via Q102 and Q103. (All circuits are now energized.)

Integrated circuit A11 converts +V to a negative voltage to provide a bias voltage (V_o) to the display (LCD). Adjustment of V_o allows the operator to optimize the viewing angle of the display.

Battery condition is monitored by one of the comparators in A103. Pin 15 is connected to the regulated reference (amplifier "bias"). When the voltage at pin 14 falls below this reference, the output (pin 16) goes low. This voltage transition is input to the microcomputer, causing it to initiate blinking of the first character on the LCD. The blinking indicates a low battery condition to the operator. This switch point occurs when the battery output is approximately 5.8 volts and allows the instrument to operate properly for about another four hours or until the battery voltage reaches its minimum.

Pressing the *LIGHT* keypad lights the LCD via Q1 and DS1. Diodes CR2 and CR3 set Q1 and R3 as a current source that maintains a constant drain on the batteries and prolongs lamp life.

2. High-Voltage Power Supply

High voltage is obtained by stepping up (T1) the voltage of the oscillator, (Q10), rectifying it (CR10) and filtering the output (C12, C13, R11). High voltage is regulated by feeding back the output to control the oscillator. At turn on, Q103 is on, causing Q10 to turn on. Current flow through T1 (pins 2, 3) feeds back via T1 (pins 4, 5), turning off (blocking) Q10. With Q10 off, blocking stops and Q10 turns on. This is a blocking oscillator, the frequency of which is limited by C16-R10, maintaining best efficiency of T1.

The high-voltage output is fed back via resistive divider R12 to a voltage follower (A102, pin 3). This stage, with a high input impedance, allows R12 to be large, presenting a minimal current load for the supply. The output of the voltage follower is then proportional to the high-voltage output. Because the input impedance to this stage is high, CR104, R113, and C114 provide filtering to reduce noise interference.

The filtered high voltage sample is input to a comparator (A102, pin 15) that is referenced to the high voltage adjusting potentiometer, R17. When the sample (pin 15) exceeds the reference (pin 14), the output at pin 16 goes low, turning off Q103, which turns off the oscillator, reducing high voltage. As the sample decreases to less than the reference, pin 16 goes high, turning Q103 on. The oscillator then runs to increase the high voltage. In this way, the high voltage is regulated to a value set by the *HV* adjusting potentiometer, R17.

The filtered output of the high voltage sample is also applied to pin 5 of A102. This stage is connected with Q104 to achieve a voltage-to-current conversion, with current through R114 proportional to high voltage. Current-to-frequency conversion is performed by the voltage comparator A102, pins 11, 12, and 10. The output at pin 10 is a frequency (F_{HV}) that is proportional to high voltage. This frequency is input to the microcomputer, which can then convert F_{HV} to a digital value and display it as high voltage.

3. Amplifier/Discriminator

Transistor Q106 and the amplifier section of A103 form a dc-coupled linear amplifier. The gain of this amplifier is set by R126 and the output impedance of the preamplifier, Q106, along with R127-R128 and the gain of the preamplifier stage. Feedback via R141 provides dc stability. The dc bias is set by R131-A132 to half of +V (2.5 volts) for a linear swing of signal on the amplifier outputs. Input protection is provided by CR103-R122, which gives a charge path for input capacitor C11 when high voltage is shorted.

The amplifier output signal is coupled to the discriminator (A103, pin 12) with capacitor C110. An output (A103, pin 10) occurs when the amplitude of the signal (pulse) exceeds the reference (A103, pin 11) set by the discriminator potentiometer, R16.

The discriminator output is divided by 2 (A105), yielding a binary input for the microcomputer. The microcomputer counts the binary transitions and calculates and displays the result as either rate or integrated value for the operator.

4. Speaker

Pulses that cause an output from the discriminator are input to the speaker control either directly or counted down for slower audible rate. In either case, the rate from the speaker is proportional to the radiation level at the detector (probe). The speaker is enabled or disabled by the microcomputer when the operator presses the *SPKR* keypad. The speaker is enabled when "SPKR" is low (0 volt).

One-half of A104 is interconnected as a monostable multivibrator (TRIGGER). The output pulse (TRIGGER) width is set by R136-C112 time constant. The other half of A104 is configured as an oscillator. It is running while the trigger output (pin 11) is low, driving the speaker via Q11 and Q12. The input signal to the trigger is differentiated by C111-R135 to prevent excessive trigger pulse widths.

The alarm is activated by "ALM" and "SPKR" set low (0 volts) by the microcomputer. This sets the trigger output low (pin 11), turning on the oscillator frequency to the speaker.

"ALM" low also activates the auxiliary alarm ("A") providing an active low output for external indication (250 mA, 20 Vdc maximum).

5. Keyboard

The switch poles are etched on the PC board. Contact between the poles is made by a conductive pad cast into each keypad. Pressing a keypad effectively short-circuits the poles.

The *ON/OFF* keypad pulls the "RST" (pin 9) of the microcomputer high. This causes the computer to reset itself and begin running its program at the program beginning (see figure 7-8). The *LIGHT* keypad causes DS1 to turn on via Q1, lighting the display.

All other keypads are inputs to the microcomputer via its input/output (I/O) port P1, which is configured as an input port under program control. These inputs are normally high. Pressing a keypad pulls the corresponding port input low.

The program running in the microcomputer performs the contact debounce, determines the switch(es) pressed, and logically performs the task(s) associated with the keyboard condition.

6. Microcomputer

Simply stated, a computer must have provisions for moving data in and out (I/O), a logical means of handling and saving data (memory), and logical elements to control I/O and memory (central processing unit, CPU). To perform any task, the CPU must execute a series of logical steps (program), which is contained in read-only memory (ROM). Memory used to save data written to or read from it is random-access memory (RAM). The RAM contains the parameters(variables), logic flags, data, scratch pads, etc., used by the program.

a. Inputs:

(1) Keyboard inputs are the operator's input to the computer. Under program control, the inputs cause the task associated with the keypad(s) to be performed (see section III).

(2) Mask (S11) switch inputs are used to signal (flag) the program to perform certain tasks differently or omit them completely (see section III).

(3) FHV is a frequency, the rate of which is proportional to the high voltage applied to the detector (probe). When the program is displaying high voltage (HV) to the user, it converts this frequency input to its HV equivalent.

(4) LO BATT (low battery) input (normally high) switches low when the low-battery condition is sensed (see "Low Voltage," section IV.4.C.1). This causes the program to blink

the first character on the display at each display update (output), warning the operator of the low-battery condition.

(5) CNT (count) input is a signal the rate of which is proportional to the radiation intensity at the detector. The rate is calculated by the program (counts/time). The calibration constant (CC) and correction factor (CF [based on detector dead time]) result in a value in radiation units as calibrated. The length of the bar graph is also calculated. The results are then output to the display for the operator.

b. Outputs:

(1) "PWR ON" (power on, active low) is output under program control to turn the power to the instrument on or off (see "Low Voltage Supply," section IV.C.1).

(2) "SPKR" (speaker on, active low) is output under program control when the *SPKR* keypad is pressed. The output is complemented at each press of the keypad. This results in a push-on/push-off action of the *SPKR* keypad (see "Speaker," section IV.C.4).

(3) "ALM" (alarm output, active low) is output activated when the program has sensed that the calculated reading has exceeded the value input by the operator for "ALM AT" (alarm setting). "SPKR" output is also activated to turn the speaker on (see "Speaker," section IV.C.4).

(4) The display is a liquid crystal (LCD) 5 x 7 dot matrix character, 2 lines of 16 characters per line. This allows the full alphanumeric ASCII character set as well as the special characters used to display the analog bar graph. The LCD is a "smart" display in that it is supported by its own microprocessor and program, thus relieving the computer of this processing load.

The computer outputs to the LCD command instructions and data to be displayed, based on the tasks being performed. These data/commands are passed to the display via the 8-bit address-data bus (A1, port P0). A command (instruction) is differentiated from data (character-to-display) by address line 14 (A1, pin 27), high equals command. The command/data are accepted by the LCD when "WR" (A1, pin 16) is low simultaneously with address line 15 (A1, pin 28) being low. This yields an address of 8000H for data and 0C000H for commands.

The LCD requires its "E" (enable, pin 6) to be strobed 0.14 microseconds (minimum) after data and addresses are stable. The quad NOR gate, (A4) and R-C time constants provided by R2-C6 and R1-C5 accomplish this.

The viewing angle of the display may be changed by varying the V_o input (pin 3).

The display is not considered to be field repairable.

c. Memory and CPU:

All RAM registers and timers are contained within the microcomputer chip and are not available to be observed. Their functions are solely to control the program (i.e., program counter and stack pointer) or for use by the program to perform its tasks (RAM and ALU).

Port P0, A1, is the address-data bus. It is bidirectional (input and output). Port P2, A1, outputs the upper eight bits of the address. On a typical program step:

(1) The address (program counter) is output at P0 (low byte) and P2 (high byte).

(2) ALE (address latch enable) is asserted and latches the address low byte in A3.

(3) PSEN (program store enable) is asserted, enabling the addressed byte to be input to the computer via P0.

(4) The program step is executed.

The program is stored in A2. On later versions of the ESP-1, the program is contained within the microcomputer chip, which eliminates A2 and A3.

SECTION 5

SECTION V. MAINTENANCE

A. CALIBRATION

1. General

The ESP-1 is an extremely versatile instrument. It is usable with a wide variety of detectors and can be calibrated in a large variety of radiation units. The end result of the calibration process is the reading provided by the instrument. The accuracy of that reading depends on the accuracy achieved in the calibration process.

Properly set up and calibrated, the instrument is inherently linear and accurate because of its microcomputer-based design. The only real limitation is the detector and its application in a particular measurement. For detector application information, see section VIII.

The calibration procedure should include testing for instrument/detector quality (plateau) as well as adjusting the reading to the radiation field at the detector. A recommended procedure follows:

NOTE

> To change the parameters that calibrate the ESP-1, the inquiry/calibration mask switch must be on (enabled). (Lower "mask" switch to the left, figure 3-1).

2. High Voltage

High-voltage readout is via an analog-to-digital conversion (ref: "Theory of Operation," section IV). The readout must be calibrated to equal the actual high voltage. Connect a voltmeter to the detector connector. The input impedance of the voltmeter must be 1000 MΩ or greater. Adjust the *HV* control for 900 V. Select the "HV" parameter using the keypads. Hold *RESET* and "+" or *RESET* and "-" until the readout is 9.00 + 02 (900 V).

3. Instrument/Detector Quality

The overall gain of the instrument is adjustable with the detector bias (high voltage) and the discriminator setting. The gain should be adjusted for the maximum detector efficiency that also provides the best stability for the measurement.

The discriminator setting (threshold input sensitivity) is set according to the detector type to be used and may be set by either of the following methods. The pulse generator method is preferred.

a. Pulse Generator (Eberline MP-1 or MP-2 recommended)

Connect a pulse generator with a calibrated pulse amplitude output to the ESP-1 detector connector. Set the ESP-1 input sensitivity as recommended by adjusting the *D* (discriminator) control until the instrument is just reading the pulse generator (see figure 3-2).

b. Voltmeter (20k ohms/volt minimum)

Measure the voltage on TEST connector, pin 11A, (see figure 3-2). Adjust the D (discriminator) control for a voltmeter reading corresponding to the proper input sensitivity referenced in Table 1.

WARNING

The high voltage should be set to the "nominal operating voltage" or less before connecting the detector to the ESP-1, to prevent damage to the detector. Check the high voltage by selecting the "HV =" parameter on the display. **Make sure** high voltage calibration has been performed.

Input Sensitivity (mV)	Vthld* (volts)
0.5	0.071
0.75	0.107
1.0	0.143
2.0	0.286
5.0	0.715
10.0	1.43
15.0	2.15

*Test connector, pin 11A (see figure 3-2).

Table 1. Input Sensitivity vs. ^{V}*thld*

c. Connect the detector to the ESP-1. With the discriminator properly set, the plateau curve can be plotted. This is the **only** data that can **truly** verify that the detector and instrument are operating properly and, with the possible exception of G-M detectors, should be plotted anytime a detector is changed or repaired.

The bias (high voltage) operating point for a G-M detector is fixed by its physical properties (i.e., size, counting gas, anode size, and fill pressure). Therefore, a check of its sensitivity or efficiency may preclude the plateau. It should be within ±20 percent of specified sensitivity at the specified operating voltage (see section VIII).

To plot the plateau (figure 5-1):

(1) Select the "HV=" parameter on the display (inquiry/calibration mode). The second line of the display shows the current average rate from the detector.

(2) Adjust the *HV* control for a low reading from the detector. Record the reading and the high voltage.

(3) Increase *HV* in steps of 50 volts, recording the high voltage reading at each step. Allow enough time at each step for the reading to stabilize.
(4) Select the operating high voltage and adjust the *HV* control accordingly.

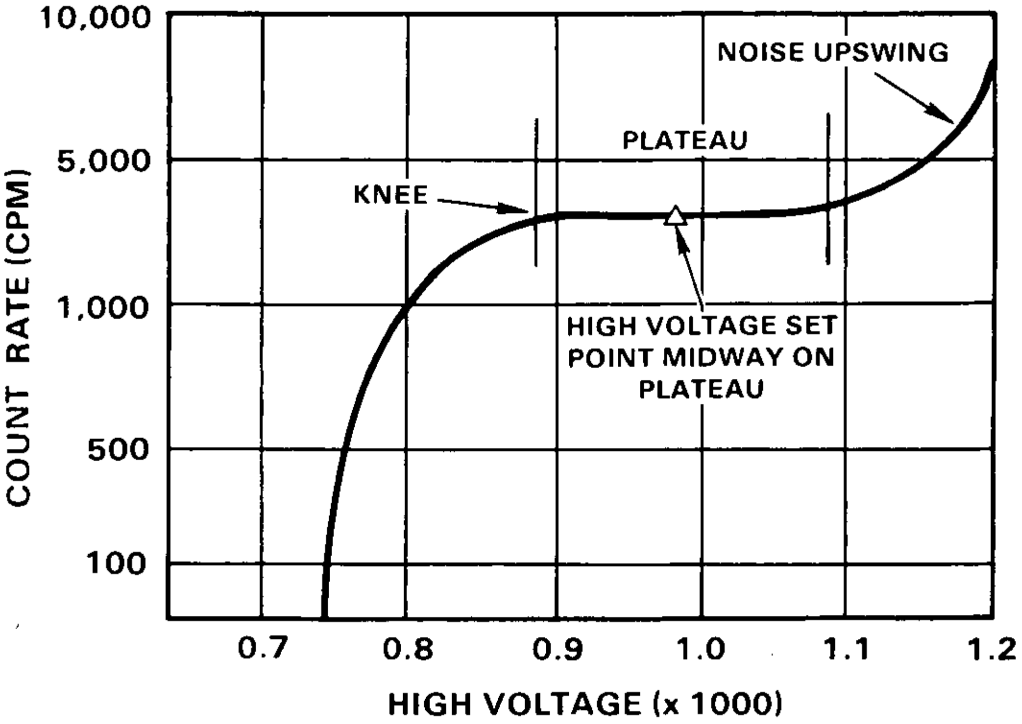


Figure 5-1. Typical Detector Plateau

4. Rate Meter Calibration

For clarity, a brief overview of the readout determination follows:

a. The average count rate is calculated each one-half second. This average is maintained in counts per second (cps) and is the basic unit for all readout displays. This average is also corrected for detector dead time (parameter DT).

b. The average (AVG) is divided by the calibration constant (parameter CC) (see table 3) and the proper factors, (units, prefix and suffix) are applied, converting the cps to the radiation units selected. This is performed and displayed every 2.0 seconds.

The calibration is performed by adjusting the CC and DT values so that the rate meter reading agrees with the radiation intensity at the detector.

Note that the dead time correction is applied to the average **before** CC. At lower count rates, this correction is insignificant.

Refer to the table for the following:

(1) Set the instrument to Inquiry/Calibration Mode (discussed in section III.C.).
(2) Set the high voltage and input sensitivity to suggested values for detector being calibrated.

(3) Set "CC=" and "DT" equal to nominal values for detector being used. (Refer to detailed operation, section III.c. , if necessary.)

(4) Select the "CC=" parameter. The current rate meter reading is always displayed on the bottom line of the LCD (this applies to all parameters, DT, HV,etc.).

(5) Expose the detector to the radiation field indicated under "set CC at" and adjust "CC=" until the "rate meter reading" matches the field strength. Note that increasing the value of "CC" will decrease the "rate meter reading" and decreasing "CC" will increase the "rate meter reading." See table 3.

(6) Select the "DT (SEC)" parameter. Expose the detector to the field indicated under "set DT at" and adjust "DT" until the "rate meter reading" matches the field strength.

(7) Recheck the reading taken in step 5. If not in agreement, repeat steps 5 and 6 until both readings are correct without having to vary the "CC" and "DT" parameters.

DETECTOR	HIGH	INPUT		NOMINAL·VALUES*****		ALIBRATION FIELDS	
MODEL	VOLTAGE	SENSITIVITY	UNITS	"CC="	"DT(SEC)"	SET "CC" AT:	SET "DT" AT:
AC-3-7	1000V**	10 mV	cpm	2.80-01***	1.20-05	30K cpm	2.5M cpm
AC-3-8	1000V**	10 mV	cpm	1.80-01***	1.20-05	30K cpm	2.5M cpm
HP-100A	1550V**	1.75 mV	cpm	******	******	******	******
HP-210,260	900V	10 mV	cpm	1.00+00*	7.50-05	72K cpm (≈20 mR/h)■	2700K cpm (≈750 mR/h)■
HP-190A	900V	10 mV	cpm	1.00+00*	3.00-04	50K cpm (≈20 mR/h)■	500K cpm (≈200 mR/h)■
HP-220A	550V	10 mV	R/h	1.55+06	7.60-05	500 mR/h	200 R/h
HP-270	900V	10 mV	mR/h	7.00+07	1.20-04	20 mR/h	1.0 R/h
HP-290	550V	10 mV	R/h	5.00+06	2.00-05	500 mR/h	25 R/h
HP-230A	900V	10 mV	cpm	1.00+00*	1.67-04	60K cpm (≈20 mR/h)■	1800K cpm (≈600 mR/h)■
LEG-1, PG-2	1000V**	10 mV	cpm	1.00+00	1.20-05	50K cpm	3000K cpm
NRD	1850V****	2 mV	mREM/h	3.00+06	1.00-05	27 mREM/h (≈1200 cpm)	fixed value
SAC-R5	800V**	10 mV	cpm	******	******	******	******
SPA-1A	650V**	10 mV	dpm	5.00-01***	1.00-05	10K cpm	fixed value
SPA-3	1000V**	10 mV	cpm	1.00+00	1.40-05	700K cpm	3000K cpm
SPA-6	1000V**	10 mV	cpm	1.00+00	1.20-05	50K cpm	3000K cpm
SPA-8	700V**	10 mV	cpm	1.00+00	3.50-05	fixed value	7.5 mR/h (≈1.0 x 10^6 cpm)
SPA-9	1000V**	10 mV	cpm	1.00+00	1.85-05	fixed value	5.0 mR/h (≈2.5 x 10^6 cpm)
WAM-4	1000V**	8 mV	dps	1.76-01	1.30-05	30K cpm	fixed value
RCM-1	1200V**	5 mV	dps	2.80-01	1.30-05	60K cpm	fixed value

*These are the values to be used when the instrument is set up to read in units of cpm. Other values must be used for "CC" if you wish to set your instrument to read in 2π cpm or 4π dpm alpha or beta efficiency.

**Detector high voltage should be set after running detector plateau.

***Set to the efficiency value determined from plateau (e.g., if 31 percent efficient, then CC = 3.10-01). If calibration is to true detector counts, "CC" should be set to 1.00 after "DT" adjustment has been performed.

**** HV setting depends on gamma rejection point. Determine by placing NRD in 10 R/h gamma field (or desired gamma field to be rejected) and adjust HV for approximately 50 cpm. Reduce HV by 50 V and verify no counts in the 10 R/h field. The HV set point is now established, and should not exceed 2200 V.

*****These nominal values may be used to set up the instrument; (1) if the calibration sheet (which has the exact values) for the instrument with the specific detector is not available; or (2) if the user wishes to use a detector which was not purchased with the instrument. Please note that the use of nominal values constitutes a generic rather than a specific calibration and, therefore, will be less accurate as compared to using values from the calibration sheet.

******The instrument is operated in the scaler mode, counts/min. The CC is set to 1.00+00 and the DT is set to 1.00-06 (fixed values).

■ Approximate values in mR/h are based on Cs-137 photons.

Figure 5-2 Suggested Calibration Levels for ESP-1, 11292-A36C

(8) At this point no further adjustment is necessary. A few linearity readings at fields in between the "CC" and "DT" settings would be an added verification of correct detector/instrument operation. Increasing the radiation field above the "DT" set point, will eventually cause an over-range alarm. This is useful in determining the upper range limit of that particular detector and instrument combination.

NOTE

The instrument may be rough calibrated by adjusting to nominal values in table. For detectors for which nominal values are not specified, the user may determine his own nominal values for ease and/or speed of the calibration process.

B. PREVENTIVE MAINTENANCE

1. Periodic Maintenance

Because of the simplicity of the ESP-1, periodic maintenance is neither time consuming nor overly frequent.

a. Install fresh batteries at least once per year.

b. Remove the bottom cover and the side access and blow out the inside with clean, dry, low-pressure air once a year.

c. Keep the outside of the case clean.

d. Open the bottom and side accesses only when calibration, maintenance, or battery change are necessary.

2. Battery Replacement

a. Turn the instrument off. If the ESP-1 is placed face down, exercise caution with the push buttons to prevent accidentally turning the instrument on. Approximately 20 minutes are available for battery change with the ESP-1 turned off.

b. Remove the large screw in the bottom cover.

c. Remove the bottom cover.

d. Dispose of the expended batteries.

CAUTION

Many of Eberline's instruments contain alkaline, carbon, lead, nickel-cadmium or lithium batteries. All batteries contain small amounts of heavy metals and other hazardous materials and must be handled and disposed of properly. Lithium batteries present the following hazards; fire, explosion or severe burn risk. Do not expose the cell contents to water. Recharge only batteries specifically designated as rechargeable and follow the manufacturers recommendations on recharging. Do not puncture, mutilate, or attempt to disassemble, incinerate, or heat above 100°C (212°F). Eberline recommends that all batteries be recycled at appropriate licensed recycling centers or disposed of as required by local ordinances and regulations.

e. Install six fresh "C" cell batteries, observing polarity as shown in the battery compartment (figure 5-2).

f. Reinstall the bottom cover and secure it with the screw.

3. Right-Side Access

a. To open, turn the fastener in the center of the access cover counterclockwise and pull straight out.

b. To close, press the cover into the opening and turn the fastener about one-half turn clockwise.

C. CORRECTIVE MAINTENANCE

1. Disassembly/Assembly

WARNING

When starting screws, exercise care. Use screw holders and other proper tools. Don't overtighten!

Use care to minimize the tension on the ribbon cables connecting the PC boards and the display. The cables are short and can be damaged.

a. Removal of PC Boards:

NOTE

For proper orientation, the front is the end with the MHV connector. The lower PC board is the board closest to the bottom cover and the upper PC board is closest to the keypad and display.

(1) Rest the ESP-1 on its top, exercising caution to prevent operation of the push-button switches.

(2) Remove the bottom cover and the batteries.

(3) Remove the nut and lockwasher that hold the coaxial connector at the front of the instrument.

(4) Remove the lower-board mounting screws (one at each corner, one in the center of the opposite end near speaker).

(5) Remove the screws on either side of the speaker (in the semicircular retainer).

(6) Lift the front edge of the lower PC board and simultaneously push the coaxial connector into the instrument case.

(7) Fold the lower PC board over the battery compartment.

(8) Remove the side access cover.

(9) Unscrew the two screws at the corners of the upper PC board.

(10) Lift the upper board and move it toward the battery compartment. The speaker will come up out of its mounting and the retainer/spacer will be freed from its position. Set the retainer/spacer aside.

(11) Step 10 pulls the upper and lower boards clear of the display assembly, which is secured by the four large screws at the corners. Loosen these screws completely.

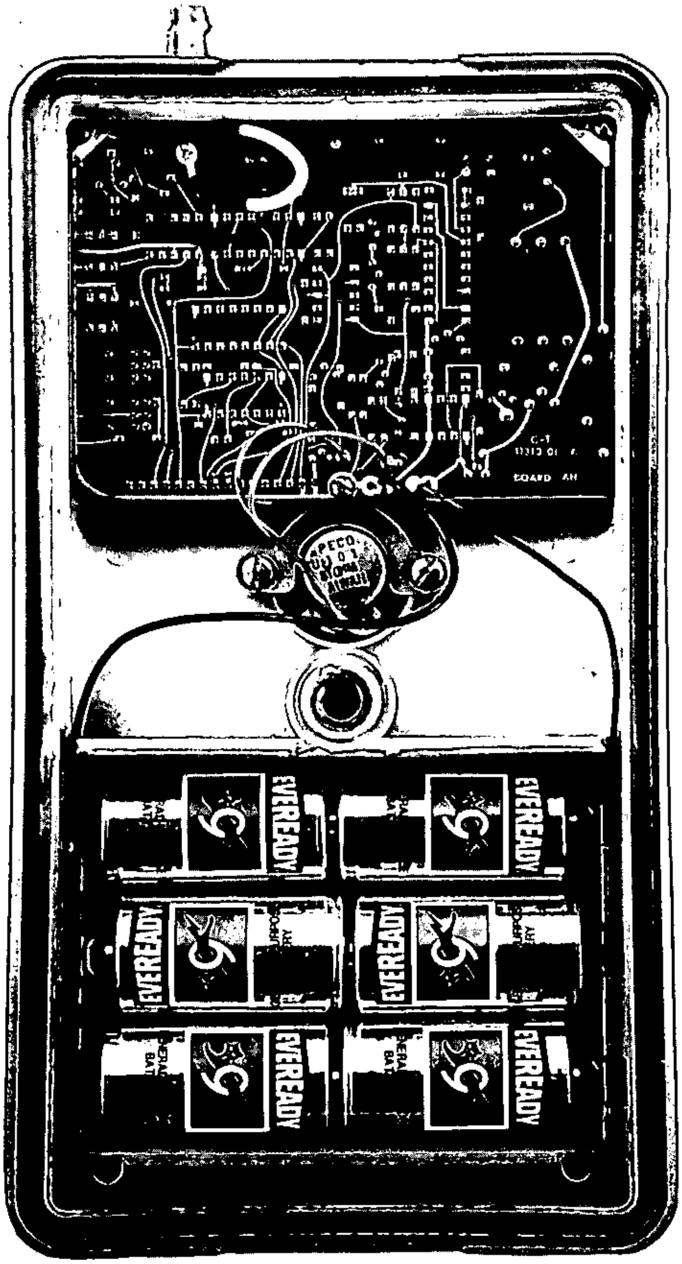
(12) Carefully lift the PC board set. The display assembly will come out of its position. Take the screws out of the Lucite mounting.

(13) The light leads extend from the button contact board to the Lucite mounting. Be careful not to break these leads.

(14) To remove the board complex completely from the case, unsolder the battery leads from the lower board.

(15) To remove the speaker, unsolder the speaker leads from the lower board.

Figure 5-3. ESP-1 with Bottom Cover Removed



b. Reinstallation of PC boards:

(1) Insert the four screws into the corner holes of the Lucite display mounting so that it holds the keypad board in place and so that the screws in the Lucite line up with the threaded holes in the case. Tighten the screws.

(2) Position the upper PC board, component side up, so that the holes in the board line up with the threaded holes in the corners of the instrument case. Insert the screws and screw them down loosely.

(3) Holding up the lower board, position the speaker in its mounting.

(4) Pulling up carefully on the lower board, raise the forward edge of the upper board enough to allow the speaker retainer's channel-shaped support for the upper board to be positioned so that the board is in the channel. The holes in the speaker retainer should be lined up with the threaded holes in the case.

(5) Making sure that the speaker leads are not pinched under the retainer, screw the retainer in tight.

(6) Tighten the two screws on the upper board.

(7) Guide the coaxial-connector lead through the cutout at the rear of the lower board.

(8) Insert the coaxial connector through the opening in the front of the case and guide the lower board into position.

(9) The hole in the center (rear edge) of the lower board should line up with the threaded hole in the speaker retainer.

(10) Insert the screw and turn it down loosely.

(11) Insert the screws to hold each corner of the upper board.

(12) Tighten the mounting screws on the lower PC board.

(13) Install the lockwasher and nut on the coaxial connector and tighten nut.

(14) If the speaker was removed, solder the speaker leads to the points on either end of the label *SPK* on the lower circuit board.

(15) If the battery leads were unsoldered, solder the red lead to the + point and the black lead to the point on the lower circuit board.

(16) Install the side access cover.

(17) Install the batteries, noting polarity.

(18) Install the bottom cover.

2. Troubleshooting

The ESP-1 uses the latest state-of-the-art components and circuitry available at the time of its design. Eberline's experience using similar components has shown them to be very reliable and trouble free. Realizing that failures and problems will occur, this section is intended to assist the technician with the task of repair.

Eberline provides a repair and calibration service at two locations in the United States and one in England for the European market. Contact Eberline for details (see front of manual).

To hold downtime to the minimum possible, users might consider changing the entire printed-circuit-board set. By maintaining a spare board set and exchanging the board set when a failure occurs, downtime (including recalibration) can probably be limited to less than one hour. The inoperative board(s) can then be repaired in-house or by Eberline without taking the ESP-1 out of service for lengthy periods of time.

NOTE

Always recalibrate after repair.

a. General Procedure

A thorough understanding of the ESP-1 circuitry and program operation is necessary before any field repairs are attempted. For component problems, review section IV, "Theory of Operation" and the schematic and logic drawings, section V. For problems related to operation, review section III "Detailed Operation" and the logic flow charts, section VII.

The incorporation of a microcomputer in the ESP-1 does not change the general approach to trouble-shooting and repair. In short, the problem must be defined, the trouble isolated, and the defect identified. Only then can effective repair be accomplished.

The circuitry used in the ESP-1 employs CMOS technology. These CMOS devices are sensitive to electrostatic discharge. To prevent damage, they should be properly grounded before and during handling.

Generally, problems can be defined in one of two categories. These would be a nonfunctioning microcomputer or a nonfunctioning counter.

NOTE

"Counter" refers to the pulse amplifier, low-voltage circuits, and high-voltage circuits.

A nonfunctioning microcomputer can be recognized by:

- No information on the display.
- Erratic display information.
- Unidentifiable/wrong characters on the display.

A nonfunctioning counter can be recognized by:

- Rate meter readout too low.
- Rate meter readout too high.
- Readout not statistical (erratic).

The first step in determining any problem should be the condition of the batteries. If battery life is shorter than specified, turn the ESP-1 *OFF* and check the drain on the batteries by inserting an ammeter in series with the "+" lead from the battery. The current should be less than 50 µA. With the ESP-1 turned *ON*, this drain should be less than 25 mA (with no alarm).

If the drain is too high in either condition, isolate the faulty component and replace it. Remember to look for leaky capacitors, but only as a last resort.

The second step is to check all voltages. Use table 4. The test connector (board edge) is reached through the side access door. Viewed through the access door, pin 1 is toward the board center, side A is on top of the board, and side B on the bottom (component side) of the board. (Refer to figure 3-1.)

TEST CONNECTOR (FIG. 3-1)	DESIGNATION	LIMITS	DESCRIPTION
10B	V_B	+6 to +10 V	Battery voltage
12B	V_C	+4.99 to +5.01 V	Regulated low voltage
9B	+V	+4.85 to +5.0 V	Switched V_C
11B	V_{BB}	+5.9 to +10 V	Switched V_B
9A	V_o	0 to -1.5 V	Display viewing angle bias
12A	GND	--	Reference

Table 4. Check Voltages

Any voltage not meeting the limits set establishes a reason for repair before proceeding. See "Repairing the Low-Voltage Supply".

b. Nonfunctioning Microcomputer

(1) Check the *TEST* switch (S1). Both switch arms should be set toward the PC board. To reinitialize the computer:

(a) Remove the batteries (at least 1).

(b) Short C1 (0.047 F capacitor). This can be reached through the side access door. (See figure 3-1.) Allow 10 seconds.

(c) Reinstall batteries.

NOTE

Reinitializing the computer resets all parameters including high-voltage calibration. Complete recalibration should be performed before putting the instrument back into service.

(2) Remove batteries and lower (amplifier/HV) board to expose the microcomputer board. Check all the integrated circuits (ICs) for proper seating in their sockets. If a loose IC is found, replace the batteries and repeat step 1 above. If the problem persists, proceed to step 3.

(3) This leaves the following possibilities:

(a) Shorted keypad switch or test connector.

(b) CR1 open.

(c) C2 shorted.

(d) A1 or X1 inoperative.

(e) A2 inoperative.

(f) A3 inoperative.

(g) A4 inoperative.

(h) Display not operating.

(i) Damaged PC board or ribbon cable(s).

c. Nonfunctioning Counter

A nonfunctioning counter usually results because either the counter has failed or the counter is noisy.

NOTE

The instrument must be turned *OFF* and back *ON* to reset an "OVERRANGE" condition. An "OVERRANGE" indication could be caused by an incorrect "DT" setting for the detector in use.

In either case, first determine that the condition is not caused by the detector or cable. The best way to do this is to connect a known good detector and cable and then check the operation.

Next, remove the lower board so its components are exposed. Visually inspect for loose and/or poorly seated components, broken wires, broken components, etc.

If the counter has failed, check:

(1) High voltage at the detector connector. Use a voltmeter with 1000 MΩ or greater input impedance. The voltage should be set for the detector being used. If not correct, see "Repairing the High Voltage Supply," section V.C.2.d. before proceeding.

(2) Amplifier output at pin 7 of A103 using an oscilloscope with an Eberline MP-2 (or MP-1) connected to the detector connector. Set the pulser to 15 mV and 40k counts per minute.

The positive pulse on the scope should be 2.0 volts or greater. If good, go to step 3 below.

If bad, the probable causes are:

(a) A103 inoperative.

(b) Q106 inoperative.

(c) CR103 shorted.

(d) C11 defective.

(3) Discriminator output at pin 10 of A103 using the scope (MP-2 still connected and set as in step 2 above). This should be a positive square pulse of 4.0 volts or greater. If good, go to step 4 below.

If bad, the probable causes are:

(a) A103 inoperative.

(b) *DISCR* control (R16) defective.

(c) A105 inoperative.

(4) Binary output at pin 9 of A105 using the scope (MP-2 still connected and set as in step 2 above). This signal should change state at the rate of the MP-2 and switch between ground and 4.0 volts or greater.

If the signal is not present, A105 is bad. If the signal is present, move the scope to pin 14 of A1 (microcomputer chip). The signal should be as above. If it is, A1 is bad. If not, check for broken wire in the ribbon jumper between boards, for damaged PC board, or bad contact at A1, pin 14.

If the counter is noisy, the most common causes of counter noise are:

(a) High voltage too high.

(b) Loose or bad ground connections.

(c) High voltage breakdown.

(d) Input sensitivity (discriminator set too sensitive).

(e) Noisy low voltage supply.

Loose or bad ground connections are best detected by visual inspection. Check for:

(f) Damaged PC board.

(g) Broken wire(s) in ribbon cables.

(h) T1 frame is not properly grounded.

If the high voltage is too high, try readjusting it (*HV* control). If it will adjust and control, then check with the detector to prove the fix. If the high voltage does not adjust and/or control, go to "Repairing the High Voltage Supply," section V.C.2.d.

Breakdown or arcing of the high voltage is normally caused by a dirty PC board, damaged component, or dirty/bad detector connector.

Input sensitivity can easily be checked using an Eberline MP-2. Check it with reference to the table in section IV for the detector being used. If the input sensitivity is too high, reset it to the proper value and check instrument operation. If it is still noisy, proceed.

Check the low voltage (V_c, +V) using a scope. The ac component should be less than 10 mV. If not, the probable causes are:

(i) A101 inoperative (if noise is on V_c).

(j) A11 inoperative.

(k) Q101 defective.

(l) Leaky filter capacitors.

d. Repairing the High Voltage Supply

NOTE

> All measurements of the high voltage require a voltmeter of 1000 MΩ or greater input impedance. Use an electrostatic voltmeter or a special high voltage arrangement such as a Fluke model 8020A with 80k-40 high voltage probe.

It is normal that the high voltage will fluctuate around the control point (± 5 percent). Adjust the high voltage by using the INTERNAL *HV* control on the PC board.

(1) No high voltage. Probable causes:

  (a) Q10 and/or T1 defective.
  (b) Q103 defective.
  (c) A102 inoperative.
  (d) CR10 defective.
  (e) C17 defective.
  (f) *HV* control (R17) defective.

(2) High voltage too high. Probable causes:

  (a) A102 inoperative.
  (b) Q103 defective.
  (c) C17 defective.
  (d) R12 defective.

(3) No HV output (computer does not display high voltage).

  (a) A102 inoperative.
  (b) Q104 defective.
  (c) Q105 defective.
  (d) Broken wire in ribbon cable.
  (e) Damaged PC board.
  (f) Bad connection A1 pin 12 to socket.
  (g) A1 inoperative.

(4) Fluctuating high voltage (see note above). Probable causes:

  (a) CR104 defective.
  (b) A102 inoperative.
  (c) R12 defective.

e. Repairing the Low-Voltage Supply

(1) V_c low

Check for excessive current drain. Isolate to faulty component by removing one IC at a time until fault is found.

Next, try to adjust for 5.00 volts. If the adjustment is satisfactory, use. If adjustment fails, A101 is inoperative. Replace it and readjust V_c for 5.00 volts.

(2) V_c high.

Try to readjust for 5.00 volts. If the adjustment is satisfactory, use. If adjustment fails, replace A101 and readjust V_c for 5.00 volts.

(3) Error in +V. Probable causes:

(a) Q101 defective.

(b) *PWR ON* from computer 0.4 volts.

(4) Error in V_{BB}. Probable causes:

(a) Q102 defective.

(b) Q13 defective. Also check Q10 and C10.

(5) Error in V_o. Probable causes:

(a) A11 inoperative.

(b) C15, C14 defective.

(c) V_o adjust, (R18) defective.

f. Speaker nonfunctioning (Note: Check S-RATE [S10] for proper setting.) Probable causes:

(1) Speaker defective.

(2) Q11, Q12 defective.

(3) A104 inoperative.

(4) S10 defective.

(5) CR101 defective.

(6) *SPKR* from computer >0.4 volt with speaker *ON*. Check ribbon cable, contact at pin 8 of A1, and board damage. If they are satisfactory, A1 or keypad switch is defective.

(7) A105 inoperative.

If speaker works but alarm does not:

(a) CR102 defective.

(b) *ALM* from computer >0.4 volt when in alarm condition. Check contact at pin 7 of A1, ribbon cable, and board damage. If they are satisfactory, A1 is inoperative.

SECTION 6

SECTION VI. PARTS LIST

The following table lists the electronic items incorporated in the ESP-1 and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

Board Set (3 boards plus display) part no. SP10A

REF DESIG	PART	DESCRIPTION	MANUFACTURER & PART NUMBER	EBERLINE PART NUMBER
A1	Integrated Circuit	Microprocessor		ICXXRM14SA
A2	Integrated Circuit	EPROM	National 27C32-Q-45	ICCMA27C32
A3	Integrated Circuit	Octal Buffer	National 74HC373 or 54HC373J	ICHCA74373
A4	Integrated Circuit	NOR Gate	74HC02	ICHCA00002
A11	Integrated Circuit	Converter	Intersil ICL7660SCPA	ICVCA76605
A101	Integrated Circuit	Regulator	Intersil ICL7663SCPA	ICAVA7663C
A102, A103	Integrated Circuit	Operational Amplifier	Motorola MC14575P	ICAOA14575
A104	Integrated Circuit	Quad 2-input NOR Gate	RCA CD4001BE	ICCMA4001B
A105	Integrated Circuit	12-Bit Binary Counter	RCA CD4040BE or SGS HFC4040BE	ICCMA4040B
C1	Capacitor	0.047 F, 5 V	NEC FA0H473Z	CPSP473MXC
C2	Capacitor	1.0 µF, 10%, 35 V, tantalum	Sprague 199D105X9035AA1	CPXX11
C3	Capacitor	15 µF, 10%, 20 V, tantalum	Sprague 199D156X9020SA1	CPXX10
C4	Capacitor	33 µF, 10%, 10 V, tantalum	Sprague 199D336X9010DA1	CPXX12
C5, C6	Capacitor	100 pF, 100 V	AVX SR151A101KAA	CPCE101P3N
C8, C101	Capacitor	0.047 µF, 20%, 50 V	Kemet C321C473M5U5CA	CPCE473P4N
C10	Capacitor	220 µF, 10%, 10 V, tantalum	CS13	CPTA221M3F
C11	Capacitor	220 pF, 10%, 3 kV	Centralab DD30-221	CPCE221P3Y

REF DESIG	PART	DESCRIPTION	MANUFACTURER & PART NUMBER	EBERLINE PART NUMBER
C12, C13	Capacitor	0.01 µF, 20%, 3 kV	Sprague 30GA-S10	CPCE103P4Y
C14, C15 C109	Capacitor	10 µF, 20%, 16 V	Sprague 199D106X0016CA1 or ITT TAP-B10K35	CPTA100M4X
C16	Capacitor	0.047 µF, 10%, 100 V	Sprague 225P47391WD3	CPPF473P3P
C17	Capacitor	3.3 µF, 20%, 35 V, tantalum	Sprague 199D335X0035BB1	CPTA335P4L
C7, C104, C107, C114	Capacitor	0.1 µF, 10%, 50 V	Centralab CW20C104K	CPCE104P3N
C106	Capacitor	0.01 µF, 20%, 50 V	AVX SR155C103KAA	CPCE103P3N
C110	Capacitor	820 pF, 10%, 100 V	Type CK12	CPCE821P3P
C111	Capacitor	22 pf, 10%, 200 V	Kemet C052C220K2X1CA	CPCE220P3R
C112	Capacitor	0.022 µF, 10%, 100 V	Kemet C062C223K1X5CA	CPCE223P3P
C113	Capacitor	1000 pF, 10%, 100 V	Centralab CN20A102K	CPCE102P3P
CR1, CR2, CR3, CR101, CR102, CR103, CR104	Diode	Silicon Switching	1N4148	CRSI1N4148
CR10	Diode	Silicon	High Voltage	CRSIVA0025
DS1	Bulb	T-1 1/4, 6 V, 60 mA incandescent	Chicago Mini, CM2114D	LPBU17
Q1, Q11, Q12,Q21, Q103	Transistor	NPN, silicon	2N4401	TRSN2N4401
Q10	Transistor	PNP, silicon	Motorola 2N4234 or National 2N4234, 2N4236	TRSP2N4234
Q13, Q101	Transistor	PNP, silicon	2N4403	TRSP2N4403
Q20	Transistor	PNP, silicon	2N4126	TRSP2N4126
Q102, Q104, Q105	Transistor	NPN, silicon	2N4124	TRSN2N4124
Q106	Transistor	NPN, silicon	2N5088	TRSN2N5088
R1, R22, R23, R107	Resistor	10k, 5%, 1/8 W, carbon film		RECC103B21

REF DESIG	PART	DESCRIPTION	MANUFACTURER & PART NUMBER	EBERLINE PART NUMBER
R2	Resistor	2.4k, 5%, 1/8 W, carbon film		RECC242B21
R3, R101	Resistor	12 Ω, 5%, 1/8 W, carbon film		RECC120B21
R4	Resistor	270 Ω, 5%, 1/8 W, carbon film		RECC271B21
R20	Resistor	1k, 5%, 1/8 W, carbon film		RECC102B21
R10	Resistor	270 Ω, 5%, 1/4 W, carbon film		RECC271B22
R11	Resistor	10M, 5%, 1/4 W, carbon film		RECC106B22
R12	Voltage Divider	1000M/1M, 5%	TRW/IRC Special	REXX22
R13	Resistor	100k, 5%, 1/4 W, carbon film		RECC104B22
R14	Resistor	22 Ω, 5%, 1/4 W, carbon film		RECC220B22
R15	Potentiometer	500k	Spectrol 64X504	PTCE504B23
R16, R17	Potentiometer	50k	Spectrol 64X503	PTCE503B33
R18	Potentiometer	25k	Spectrol 64X253	PTCE253B13
R21,R109, R113, R151	Resistor	47k, 5%, 1/8 W, carbon film		RECC473B21
R102	Resistor	3.0M, 5%, 1/8 W, carbon film		RECC305B21
R103	Resistor	910k, 5%, 1/8 W, carbon film		RECC914B21
R104	Resistor	20k, 5%, 1/8 W, carbon film		RECC203B21
R105,	Resistor	75k, 5%, 1/8 W, carbon film		RECC753B21
R106	Resistor	18k, 5%, 1/8 W, carbon film		RECC183B21
R108, R115	Resistor	200k, 5%, 1/8 W, carbon film		RECC204B21
R110	Resistor	30k, 5%, 1/8 W, carbon film		RECC303B21
R111, R120,R121, R127,R140	Resistor	22k, 5%, 1/8 W, carbon film		RECC223B21
R112	Resistor	470 Ω, 5%, 1/8 W, carbon film		RECC471B21
R114	Resistor	49.9k, 1%	RN50	RECE493B11
R116	Resistor	390k, 5%, 1/8 W, carbon film		RECC394B21
R117	Resistor	2.1k, 1%	RN50	RECE212B11

REF DESIG	PART	DESCRIPTION	MANUFACTURER & PART NUMBER	EBERLINE PART NUMBER
R125	Resistor	2.2k, 5%, 1/8 W, carbon film		RECC222B21
R118	Resistor	4.7k, 5%, 1/8 W, carbon film		RECC472B21
R5, R119	Resistor	1M, 5%, 1/8 W, carbon film		RECC105B21
R122	Resistor	2k, 5%, 1/8 W, carbon film		RECC202B21
R123	Resistor	39k, 5%, 1/8 W, carbon film		RECC393B21
R124	Resistor	68k, 5%, 1/8 W, carbon film		RECC683B21
R126, 129,R141	Resistor	150k, 5%, 1/8 W, carbon film		RECC154B21
R128, R135	Resistor	100k, 5%, 1/8 W, carbon film		RECC104B21
R131,	Resistor	5.1k, 5%, 1/8 W	RN50	RECC512B21
R133	Resistor	130k, 1%,	RN50	RECE134B11
R134	Resistor	100k, 1%,	RN50	RECE104B11
R137	Resistor	510k, 5%, 1/8 W, carbon film		RECC514B21
R138	Resistor	270k, 5%, 1/8 W, carbon film		RECC274B21
R139	Resistor	3.3k, 5%, 1/8 W, carbon film		RECC332B21
S1	Switch	Dip Toggle DPST	Alco ADP-02	SWTO1
S10, S11	Switch SPDT	Dual Slide right angle	Alco TSD21DDG-RA	SWSL7
T1	Transformer	Blocking oscillator	Microtran M8149	TFHV5
X1	Crystal	6.0 MHz, 0.015%	MP-060	CYOS9
	Speaker O-ring	Buna-N	Parker 2-021	ORBN2021
	Speaker	1-inch-diameter x 0.6 deep, 8Ω, .15W	Sepco U101	ADSP4
	Display	2-line x 16-character (LCD)	Hitachi LM016L	OPDS19
	Keypad			ZP11292006
	Case	Upper, Lower		ZP11292029
	Screw	Lower-case retaining screw	3/8 - 16 x 1 flat-head, stainless-steel	SCFH3716
	Ribbon Cable	Keyboard/Computer Board Cable (9-conductor)	Special	WRFC092601

REF DESIG	PART	DESCRIPTION	MANUFACTURER & PART NUMBER	EBERLINE PART NUMBER
	Ribbon Cable	Display/Computer Board Cable (14-conductor)	Special	WRFC142602
	Ribbon Cable	Computer Board/ Cable Amp.--High Voltage Board (16-conductor)	Special	WRFC162603
	Access door			ZP11292012
	Access door latch		Southco 84-20-120-10	HDFA10
	Battery	1.5 V, "C" cell, alkaline		BTAK2
	Display lens			ZP11292023
	Speaker Retainer			ZX11292013

SECTION 7

SECTION VII. DIAGRAMS

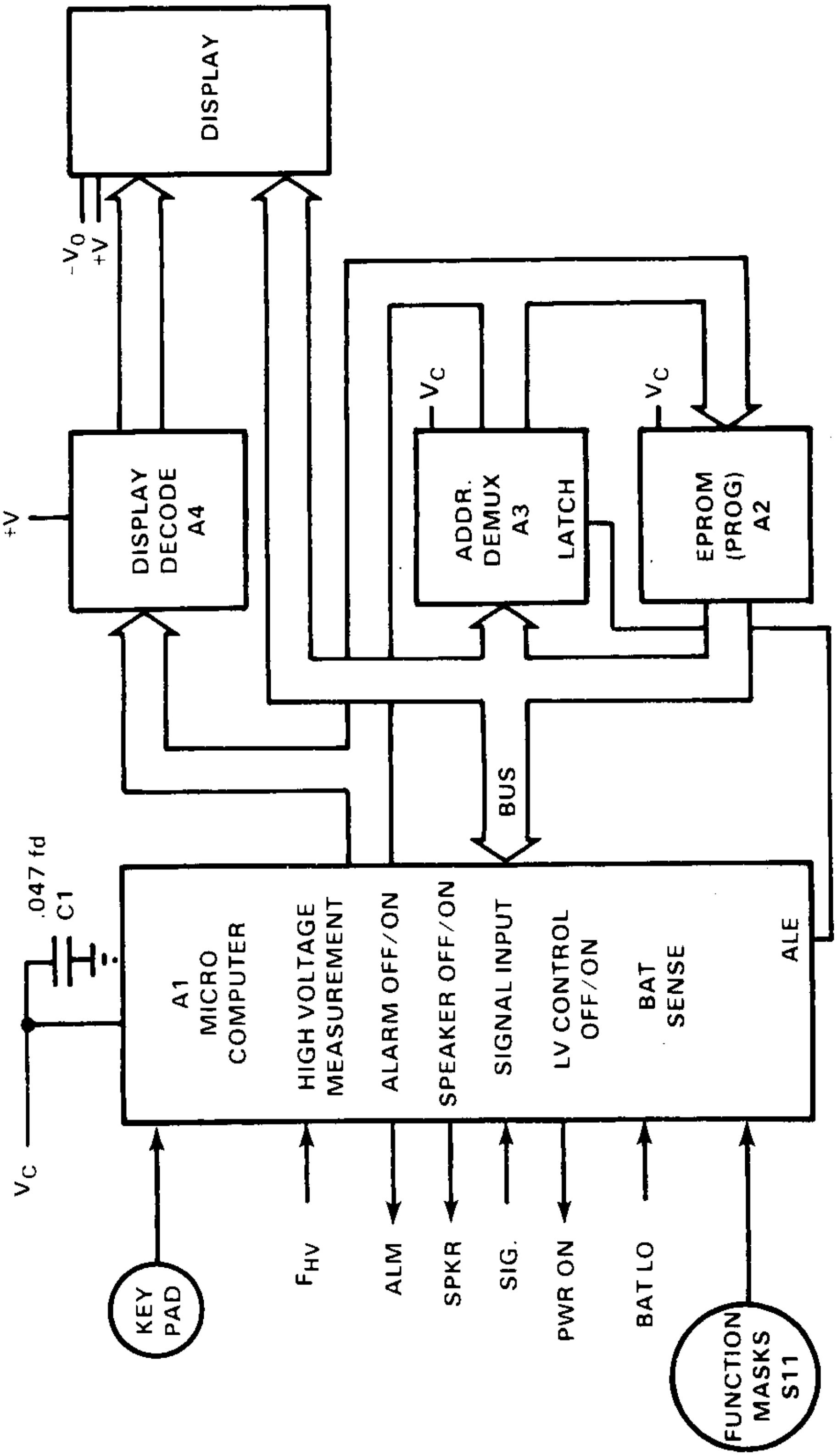


Figure 7-1. Microcomputer Functional Block Diagram

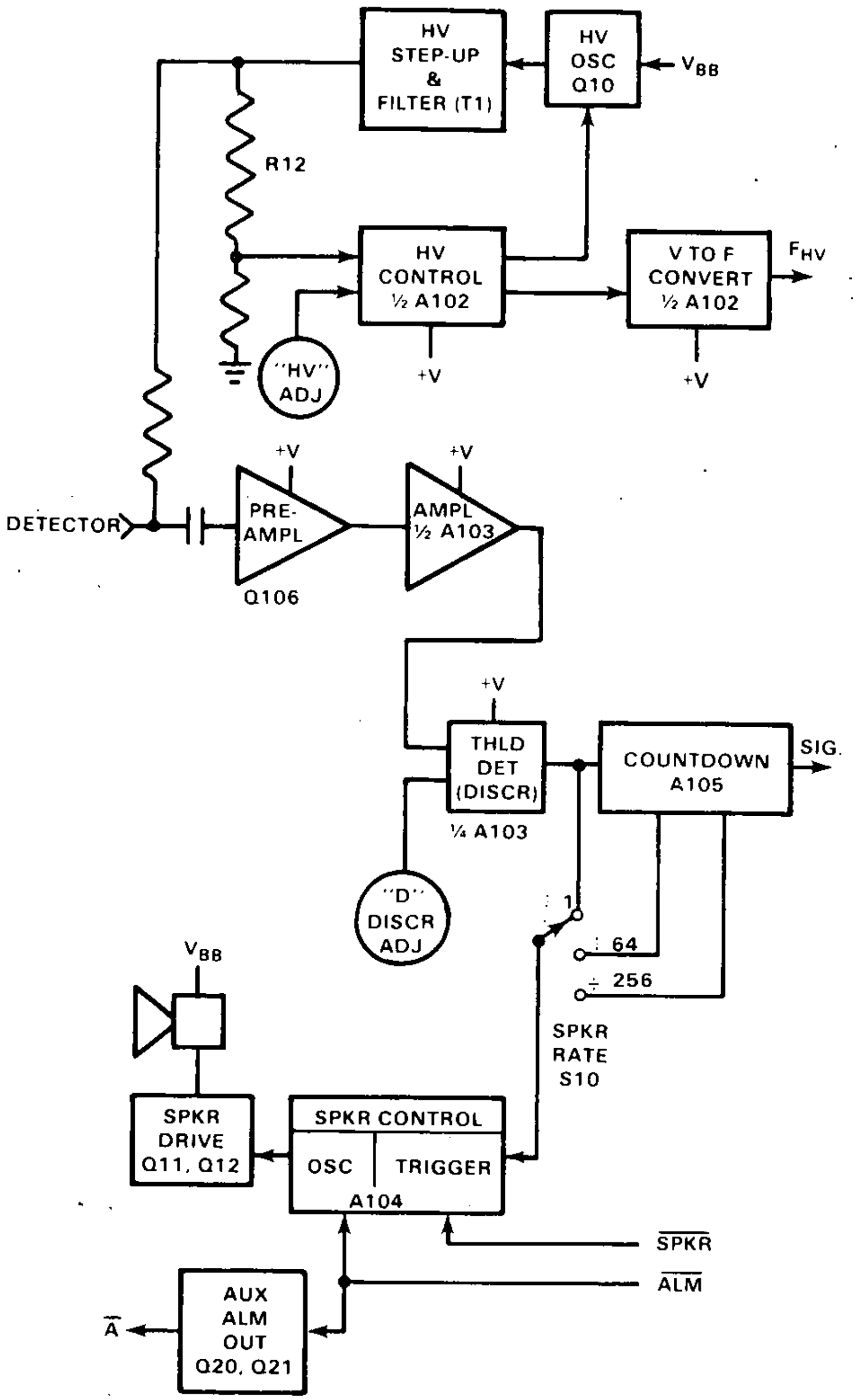


Figure 7-2. Functional Block Diagram for Amplifier, High Voltage and Speaker

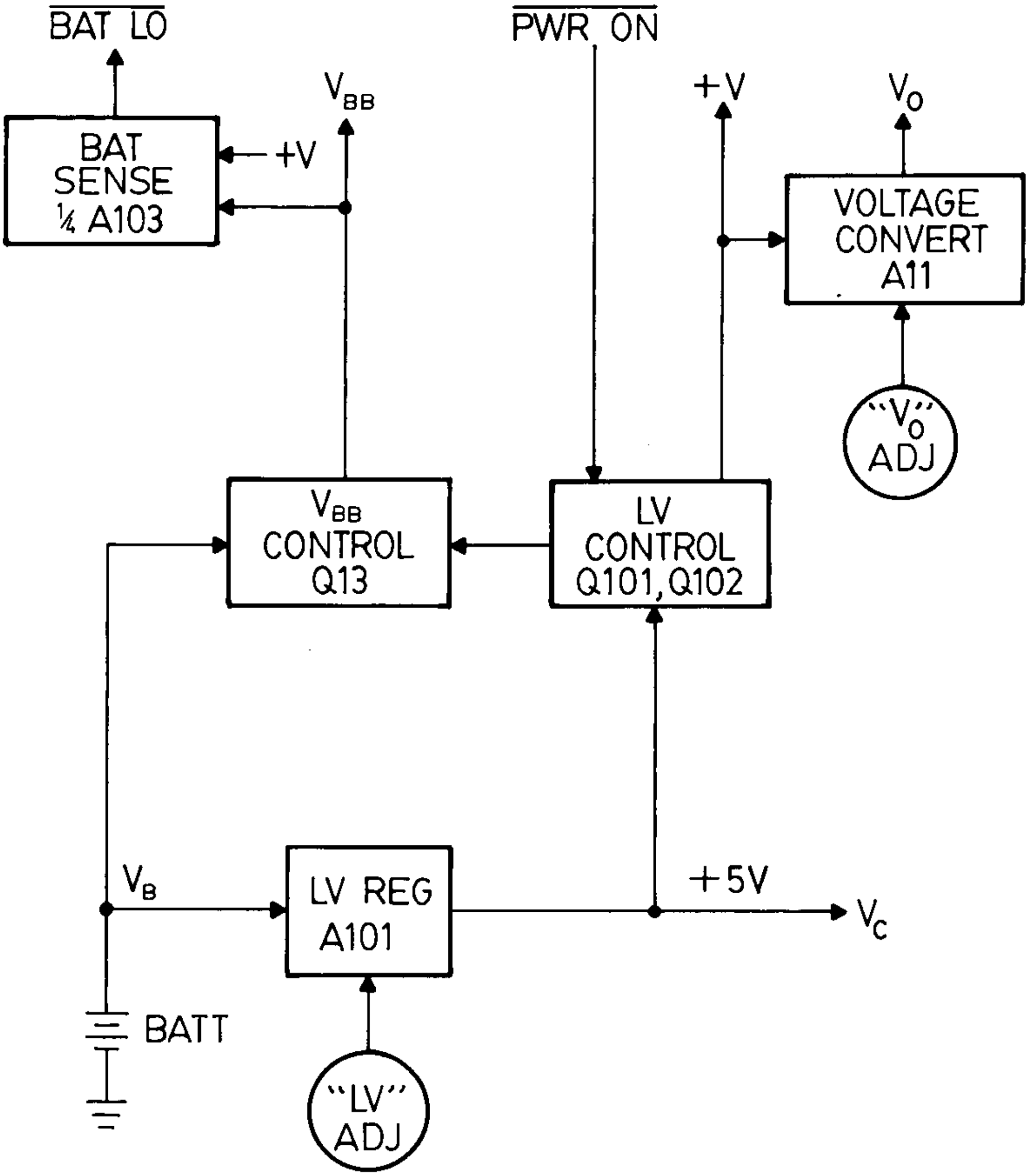


Figure 7-3. Low Voltage Functional Block Diagram

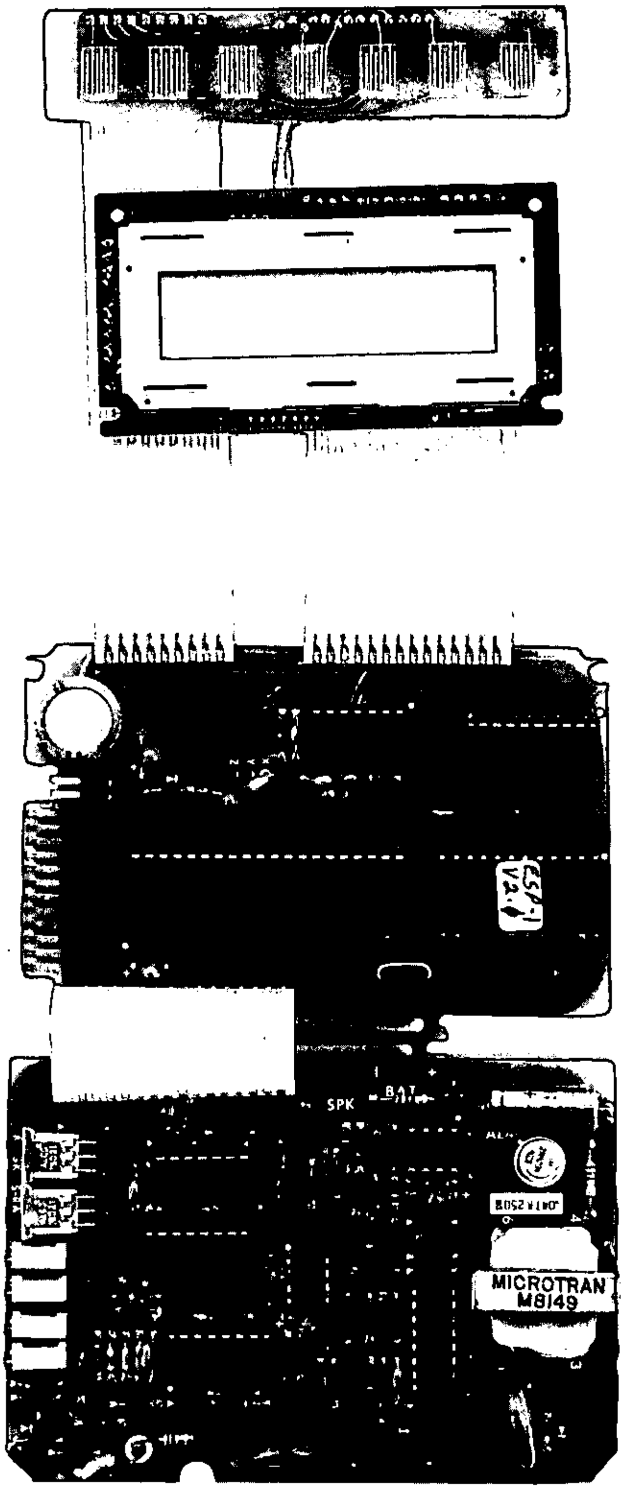


Figure 7-4. Printed Circuit Board Set

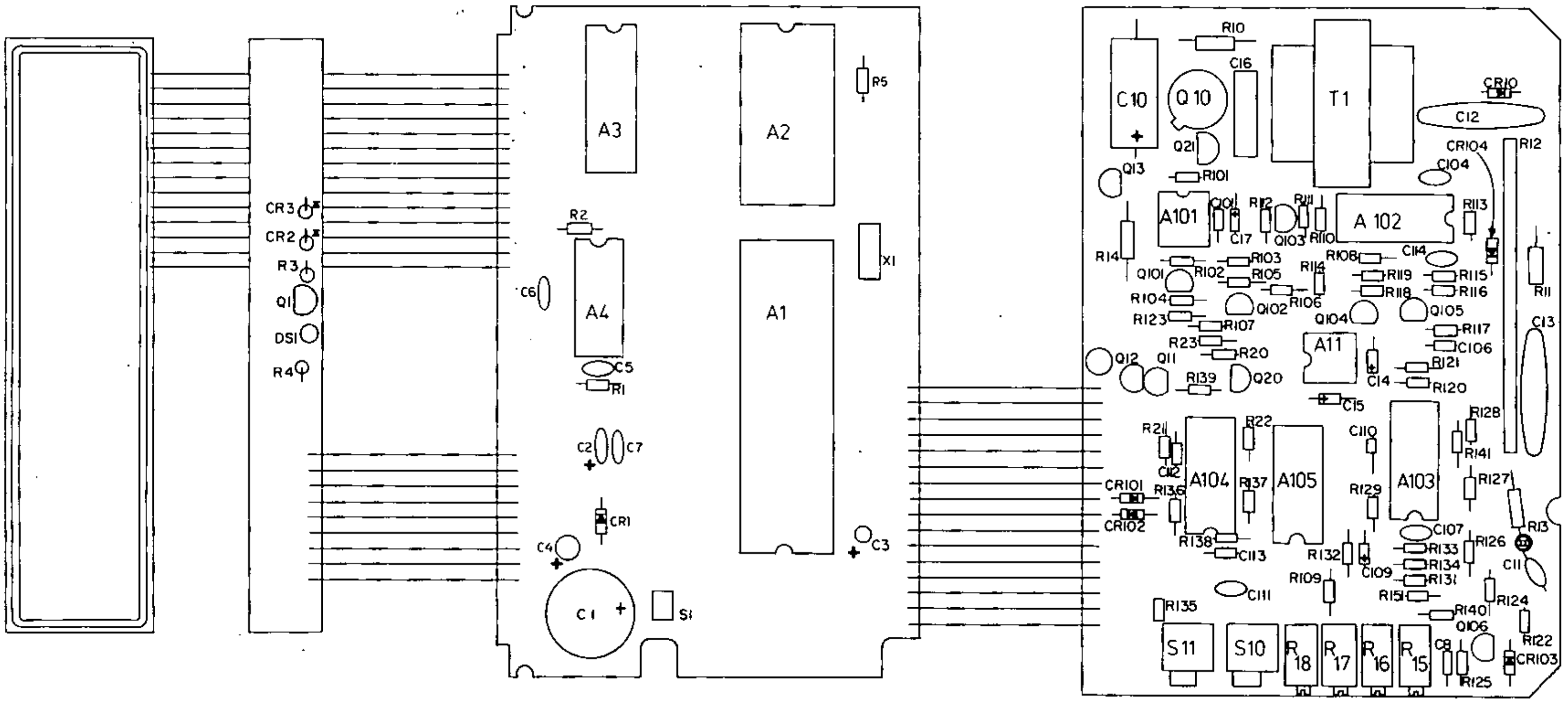


Figure 7-5. Component Layout, 11292-C17c

NOTES:
1. RESISTORS ARE $\frac{1}{8}$W, 5 %, EXCEPT AS NOTED.
RESISTOR VALUES ARE IN OHMS.
K=10^3, M=10^6
2. CAPACITOR VALUES ARE IN MICROFARADS EXCEPT AS NOTED.

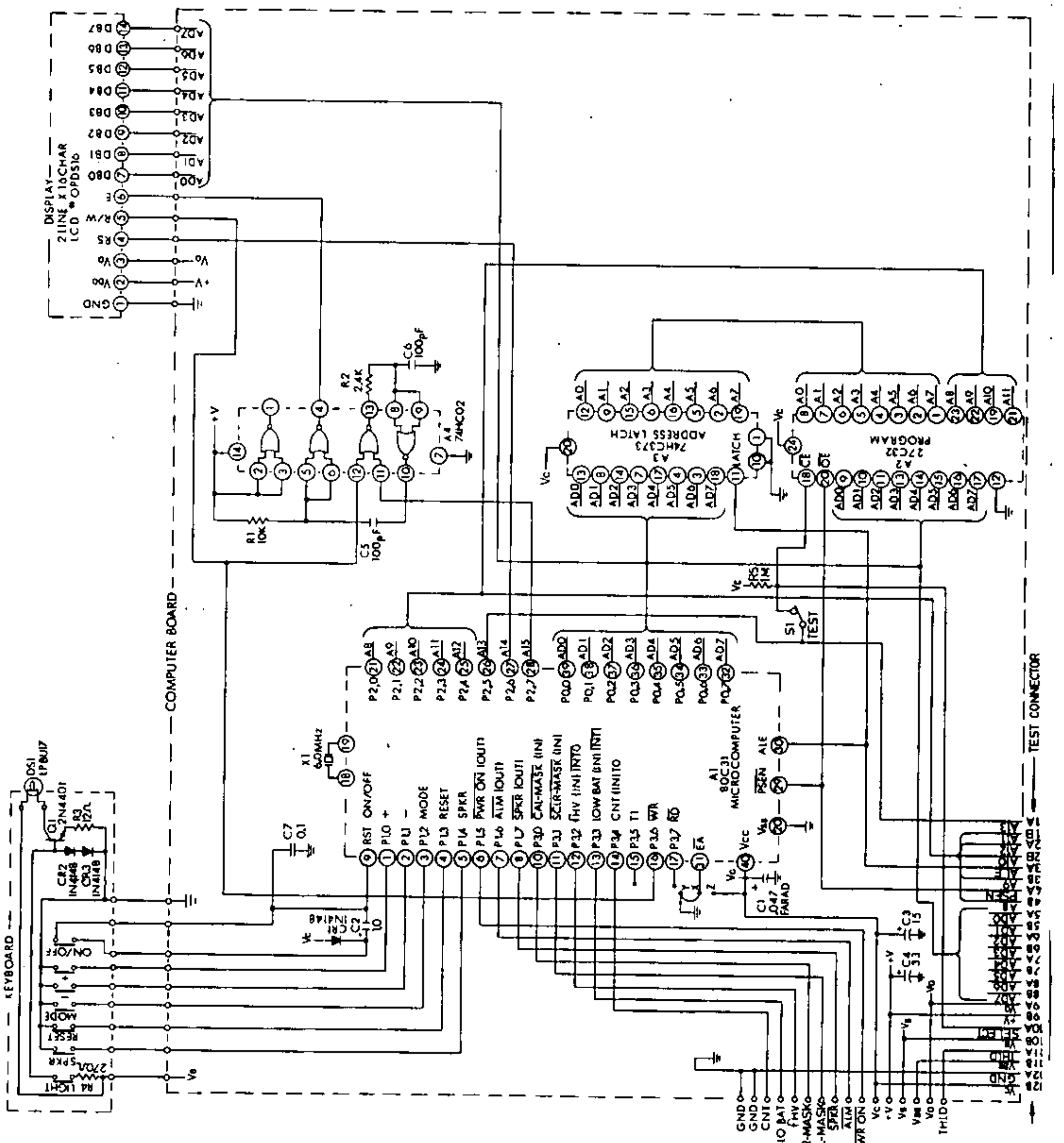


Figure 7-6, Amplifier/High Voltage Schematic, 11292-D04^G, Sheet 1 of 2

NOTES:
1. RESISTORS ARE $\frac{1}{8}$W, 5%, EXCEPT AS NOTED.
RESISTOR VALUES ARE IN OHMS, $K=10^3$, $M=10^6$
2. CAPACITOR VALUES ARE IN MICROFARADS
EXCEPT AS NOTED.

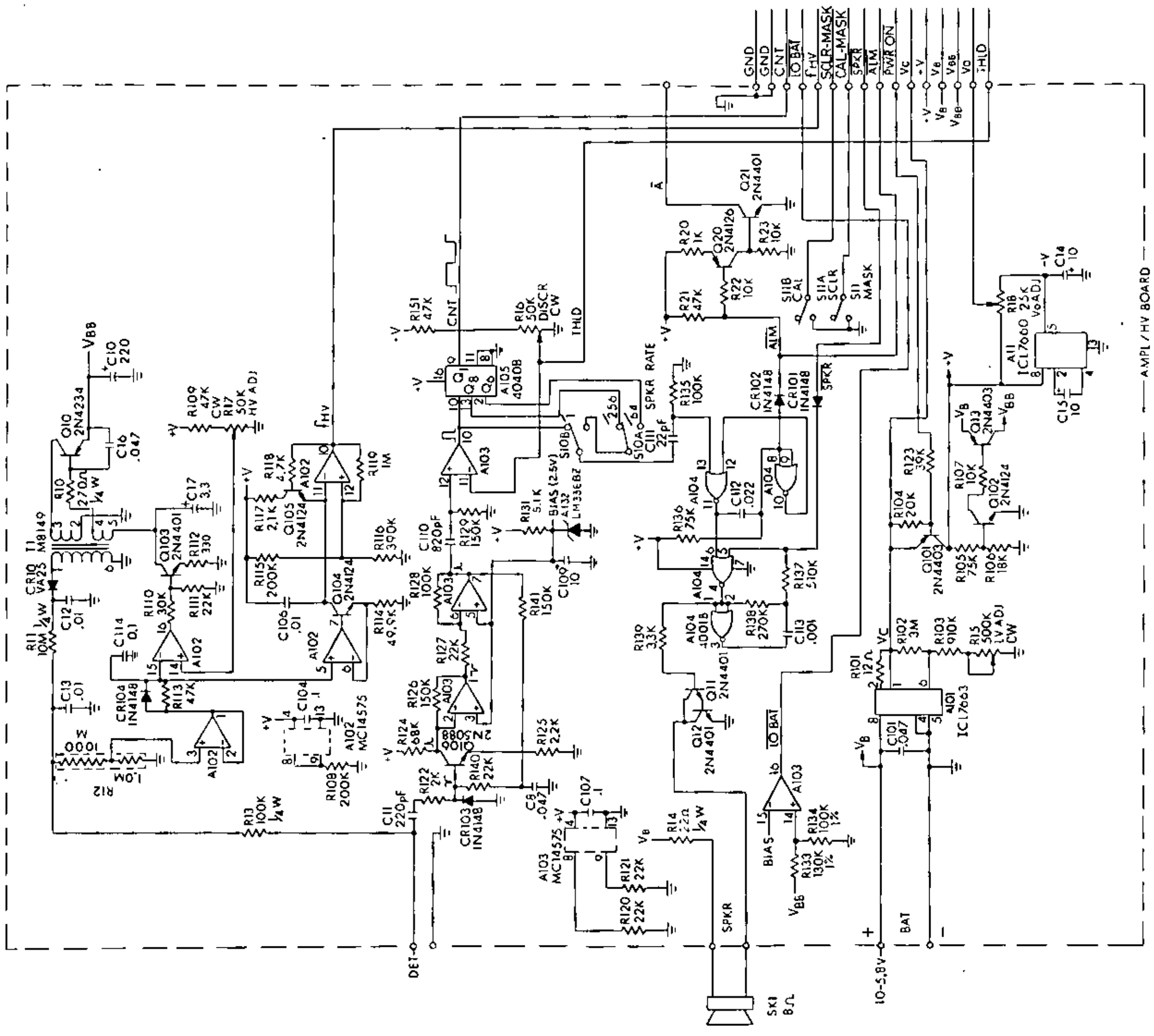
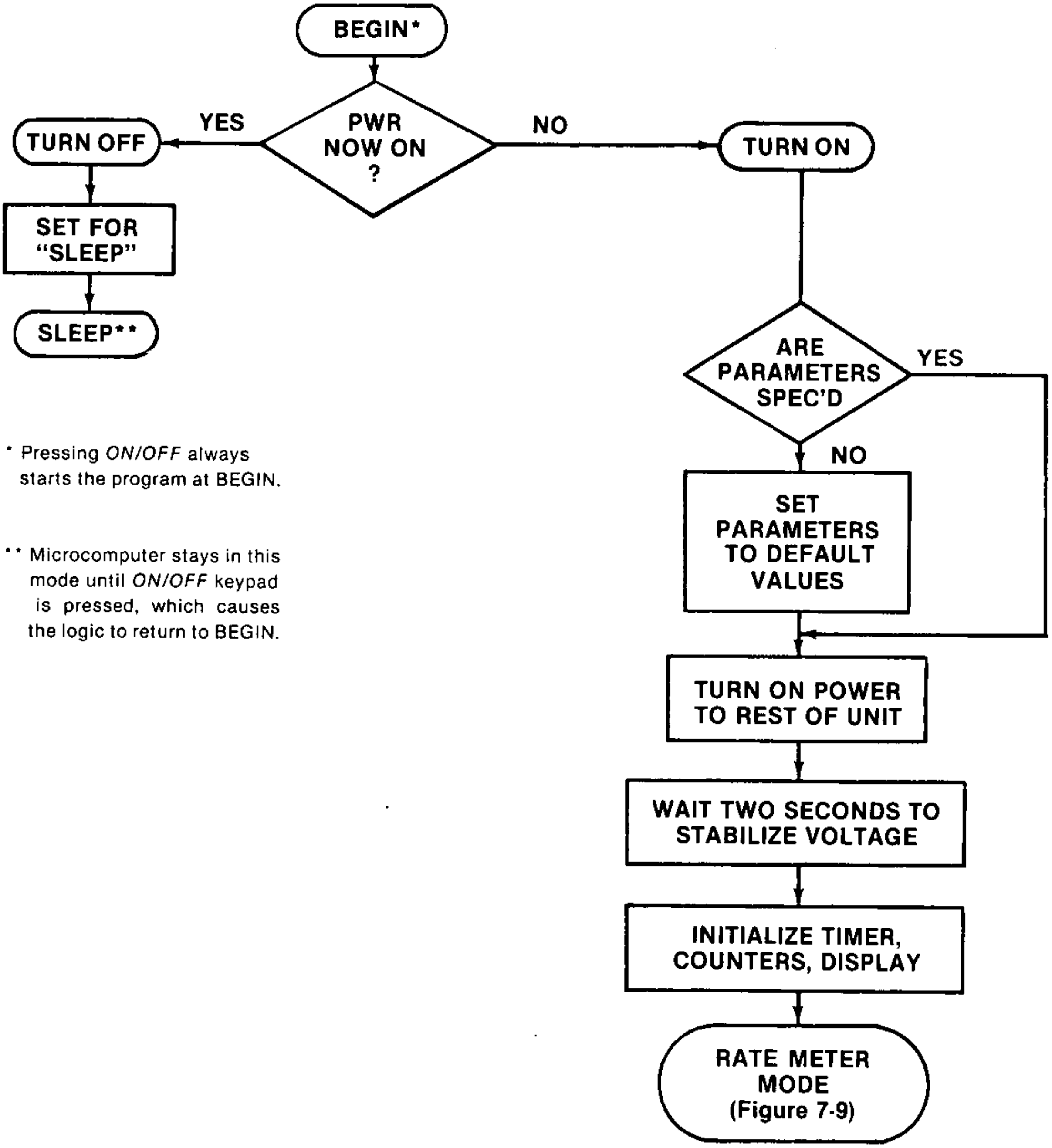


Figure 7-6, Amplifier/High Voltage Schematic, 11292-D04^G, Sheet 2 of 2


BEGIN*
PWR NOW ON ?
YES
NO
TURN OFF
SET FOR "SLEEP"
SLEEP**
TURN ON
ARE PARAMETERS SPEC'D
YES
NO
SET PARAMETERS TO DEFAULT VALUES
TURN ON POWER TO REST OF UNIT
WAIT TWO SECONDS TO STABILIZE VOLTAGE
INITIALIZE TIMER, COUNTERS, DISPLAY
RATE METER MODE (Figure 7-9)

* Pressing *ON/OFF* always starts the program at BEGIN.

** Microcomputer stays in this mode until *ON/OFF* keypad is pressed, which causes the logic to return to BEGIN.

Figure 7-7. Logic Flow-Applying Power

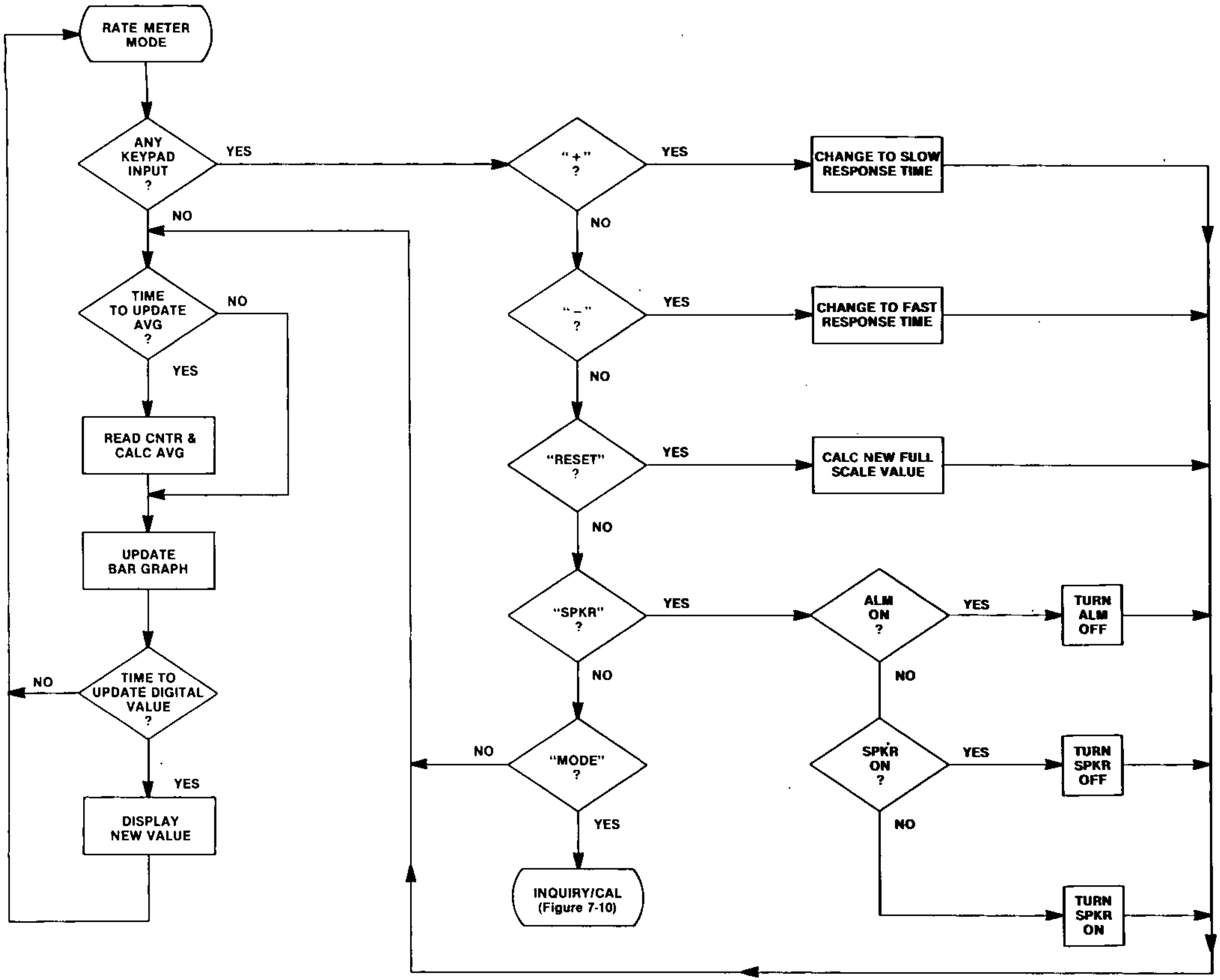


Figure 7-8. Logic Flow-Rate Meter Mode

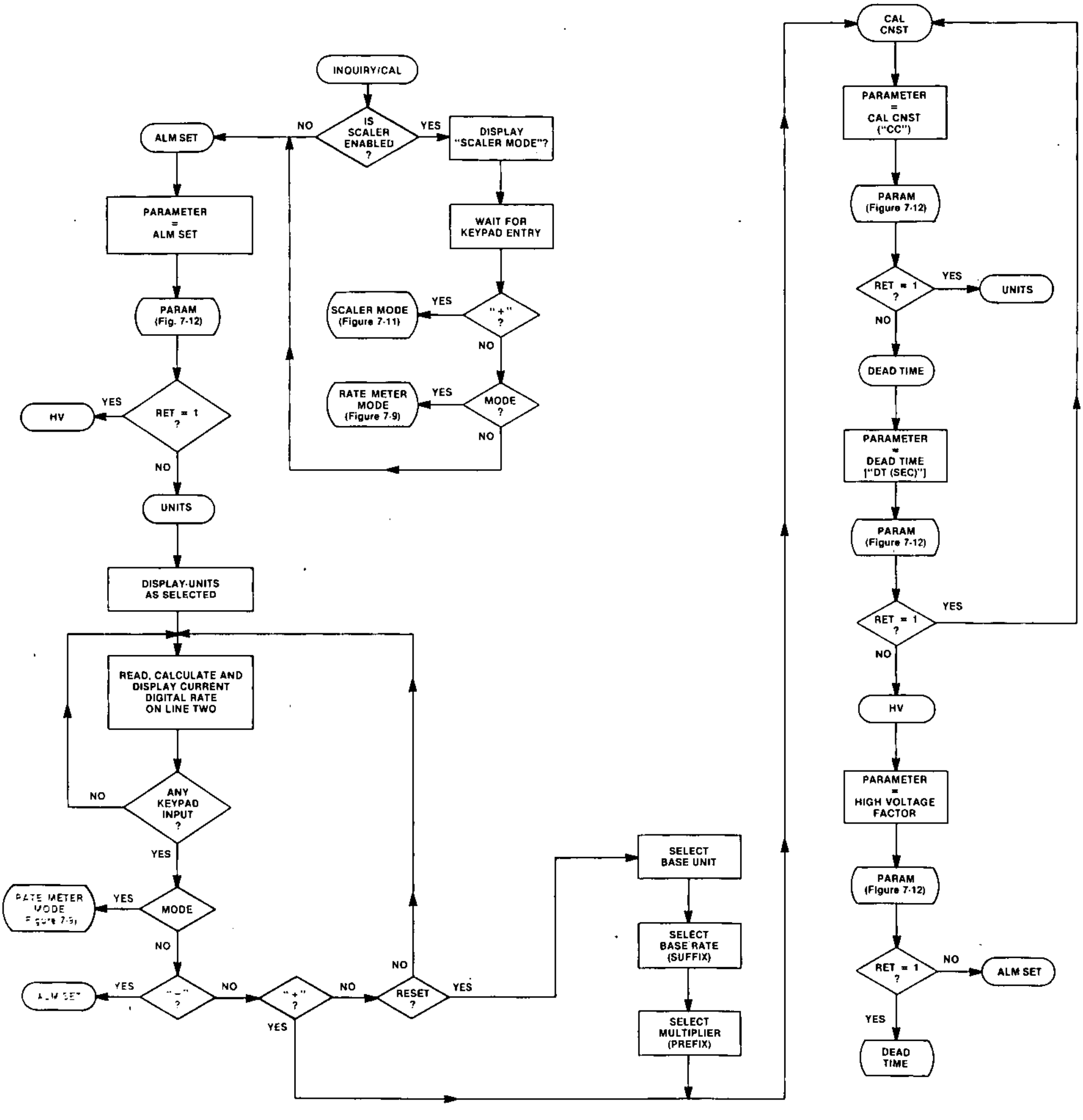


Figure 7-9. Logic Flow-Inquiry/Calibration

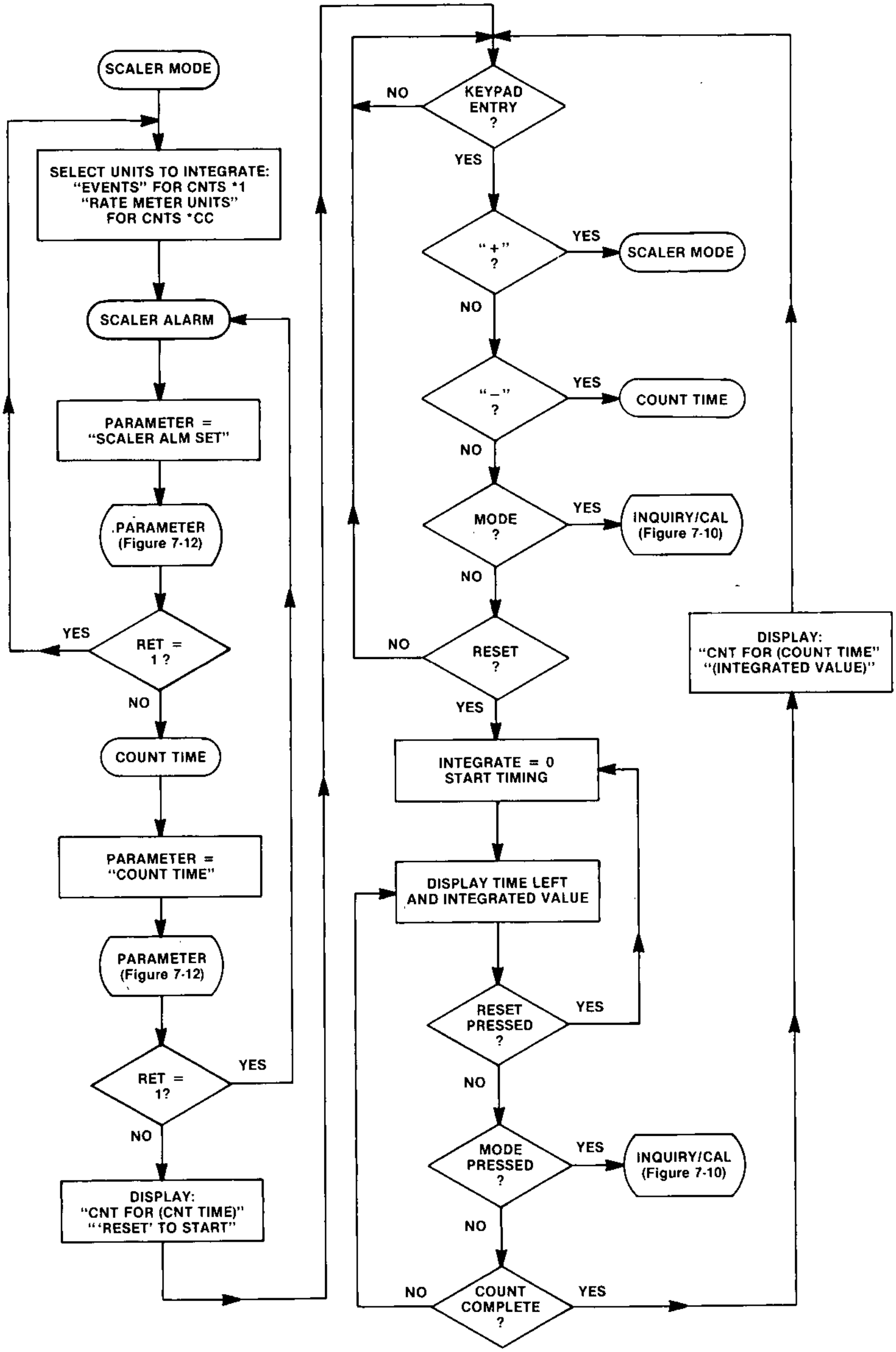


Figure 7-10. Logic Flow-Scaler Mode

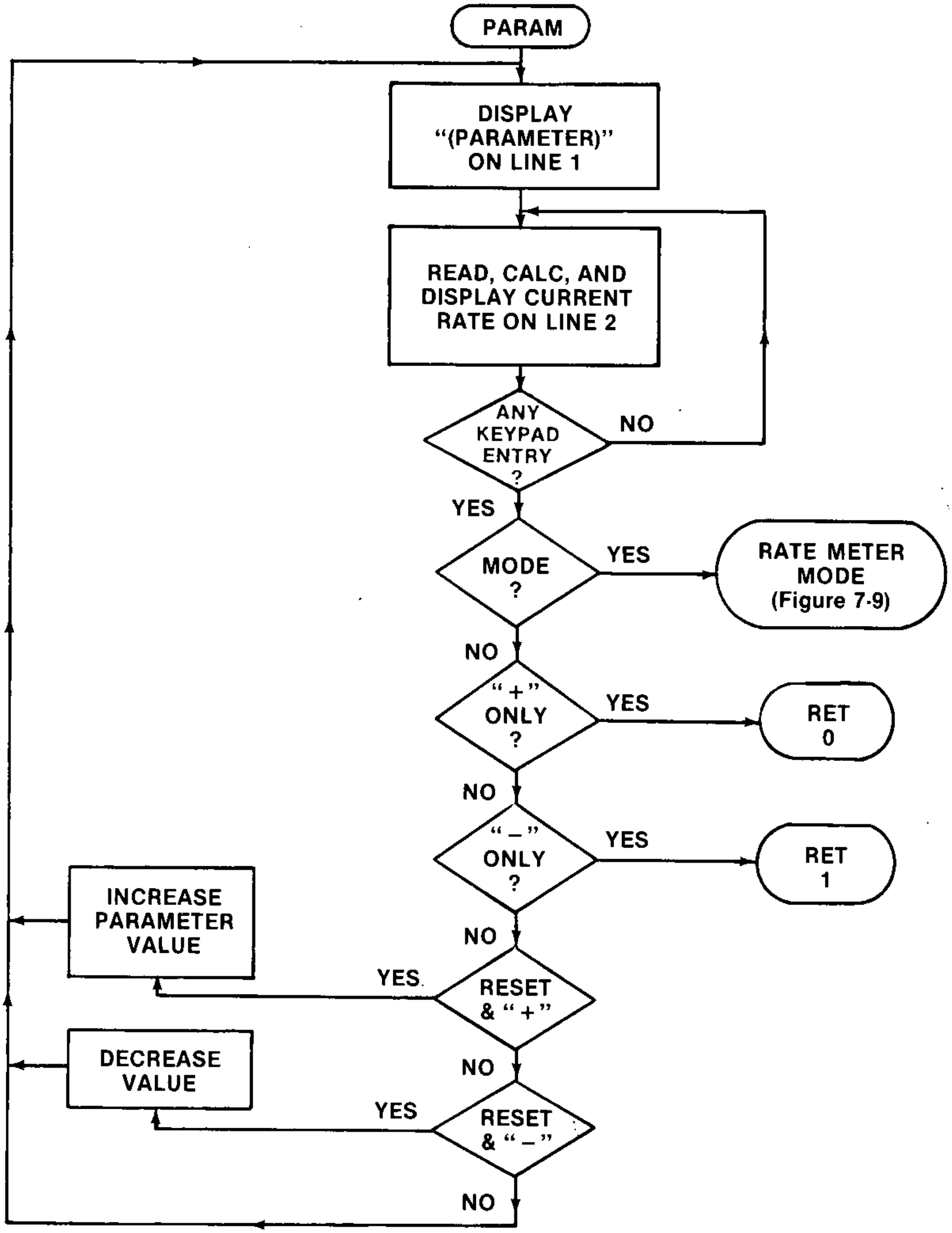


Figure 7-11. Logic Flow-Parameter Setting

SECTION 8

SECTION VIII. DETECTORS AND ACCESSORIES

Detectors Recommended for "SMART" Digital Instruments

Model No.	Type Measurement	Useful Range
AC-3	Alpha Contamination	Background to 33,000 cnt/s
HP-100A	Alpha, Beta, Gamma Contamination	Background to 33,000 cnt/s
HP-190A	Beta-gamma Contamination 1 1/8 inch window	Background to 25,000 cnt/s
HP-210	Beta-gamma Contamination 2 inch window	Background to 66,000 cnt/s
HP-220A	Gamma Exposure or Exposure Rate Directional Shield	Background to 200 R/h
HP-230A	Beta-Gamma Contamination 7/8 inch window	Background to 1000 mR/h
HP-260	Beta-gamma Contamination	Background to 66,000 cnt/s
HP-270	Gamma Exposure or Exposure Rate	Background to 2500 mR/h
HP-280	Neutron Flux (used with NRD)	Background to 44,000 cnts/s
HP-290	Gamma Exposure or Exposure Rate	0.005 to 50 R/h
LEG-1	Low Energy Gamma or X-Ray 20 to 70 KeV	Background to 33,000 cnt/s
NRD	Neutron Dose Equivalent or dose Equivalent Rate	0.001 to 60 rem/h
PG-2	High Sensitivity Gamma 10 KeV to 100 KeV	Background to 25k cnts/s
RD-14	Alpha or Beta Filter Samples Up to 4 1/2 inch diameter	Background to 33,000 cnts/s
SAC-R5	Lucas Cell Counter	Background to 33,000 cnts/s
SPA-1A	Alpha Filter Samples	Background to 50,000 cnts/s
SPA-3	High Sensitivity Gamma 40 KeV to 1 MeV	Background to 25,000 cnt/s
SPA-6	Medium Sensitivity Gamma 40 KeV to 1 MeV	Background to 25,000 cnt/s
SPA-8	Medium Sensitivity Gamma 40 KeV to 400 KeV	Background to 25,000 cnts/s
SPA-9	High Sensitivity Gamma 40 KeV to 250 KeV	Background to 25k cnts/s
WAM-4	4π Gamma	Background to 33,000 cnts/s

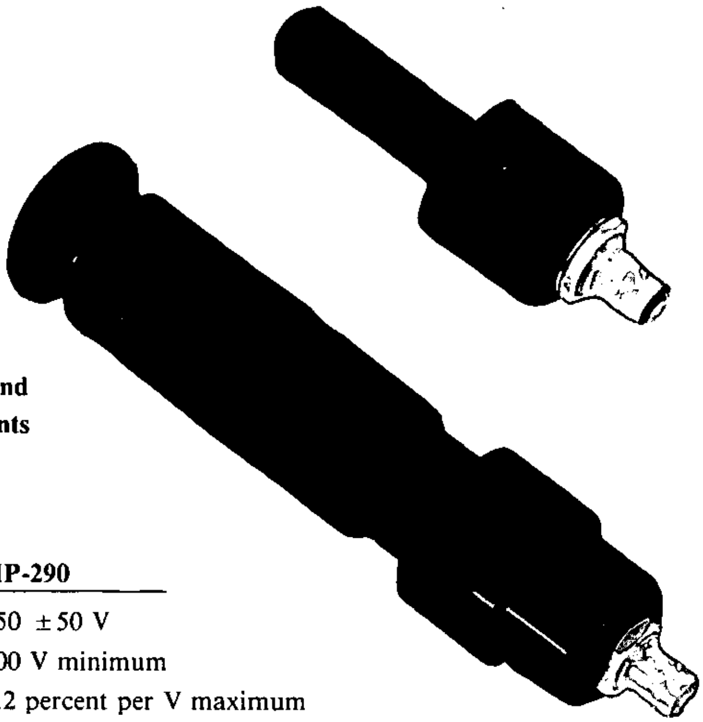
11292-A37A

Models HP-270 and HP-290 Hand Probes

A. GENERAL DESCRIPTION

The HP-270 is an excellent general purpose G-M probe with energy compensation and a beta shield, making it the choice for most health physics applications. The energy compensation permits reliable exposure rate measurement from background to 3000 mR/h.

The HP-290 is a higher range G-M probe with energy compensation, providing reliable exposure rate measurement from 0.1 mR/h to 40 R/h.

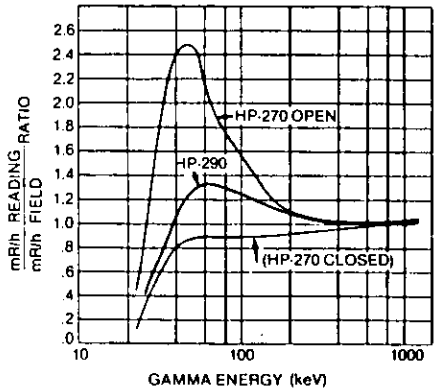


Model HP-270

- **Energy Compensated for Gamma and Exposure Rate Measurements**

B. SPECIFICATIONS

	HP-270	HP-290
Operating Voltage:	900 ±50 V	550 ±50 V
Plateau Length:	100 V minimum	100 V minimum
Plateau Slope:	0.1 percent per V maximum	0.2 percent per V maximum
Dead Time:	100 μs maximum	20 μs maximum
Temperature Range:	−40 °F to +167 °F (−40 °C to +75 °C)	−40 °F to +167 °F (−40 °C to +75 °C)
Wall Thickness:	30 mg/cm^2 (tube only)	90 mg/cm^2 (tube only)
Wall Material:	Stainless steel	Stainless steel
Gamma Sensitivity:	≅1200 cpm/mR/h (^{137}Cs)	≅80 cpm/mR/h (^{137}Cs)
Energy Response:	See curve	See curve
Housing:	ABS plastic	ABS plastic
Connector:	BNC series coaxial	BNC series coaxial
Size:	1 3/8 inches in diameter × 6 inches long (3.5 cm × 15.2 cm)	1 1/8 inches in diameter × 3½ inches long (2.9 cm × 8.9 cm)
Weight:	5 ounces (142 g)	2 ounces (57 g)



C. AVAILABLE ACCESSORIES

Cable: CA-16-60

Check Source: CS-7A

Models HP-210 and HP-260
Hand Probes

A. GENERAL DESCRIPTION

These hand probes provide a sensitive beta detector featuring a "Pancake" GM tube with a thin mica window. They are designed for contamination surveys on personnel, table tops, floors and equipment. The open window, which is protected by a sturdy wire screen, permits useful beta sensitivities down to 40 keV. The detector is alpha sensitive (above 3 MeV).

The HP210-L with a lead shield and the HP-210T with a tungsten shield permit relatively low-level beta monitoring in a gamma background. The shielding ration for ^{60}Co gamma (front: back) is 4:1. The HP-260 is a lightweight probe without any gamma shielding.

B. SPECIFICATIONS

Operating Voltage: 900 ±50 V

Plateau Length: 100 V minimum

Plateau Slope: 0.1 percent per V maximum

Dead Time: 50 μs maximum

Temperature Range: −22 °F to +167 °F (−30 °C to +75 °C)

Mica Window Thickness: 1.4 to 2.0 mg/cm^2.

Mica Window Size: 1.75-inch-diameter (4.45 cm); 2.4 in^2 (15.5 cm^2)

Gamma Sensitivity: ≅3600 cpm/mR/h (^{137}Cs) **(into window)**

***Beta Efficiency:**
- ≅45 percent ^{90}Sr-^{90}Y
- ≅30 percent ^{99}Tc
- ≅10 percent ^{14}C

Alpha Sensitivity: 3 MeV at window

Connector: BNC series coaxial

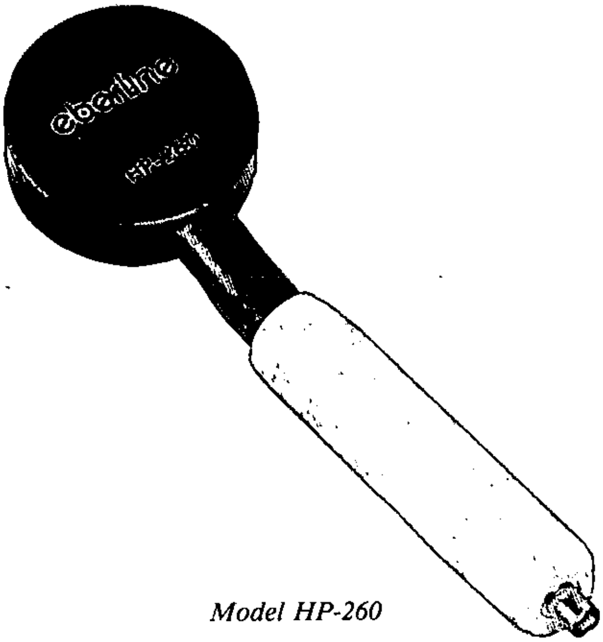
C. AVAILABLE ACCESSORIES

Sample Holder: SH-4A for use with HP-210

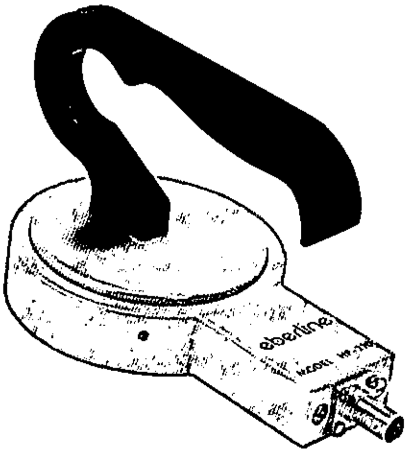
Cable: CA-16-60

Check Source: CS-7A

*Efficiencies with screen in place. Screen removal will increase efficiency by ≅45 percent of stated value. Efficiencies listed as percentage of 2π emission rate, from a one-inch-diameter source.



Model HP-260



Model HP-210T/Model HP-210L

Model NRD
Neutron rem Detector

A. GENERAL DESCRIPTION

The Model NRD neutron rem detector is a nine-inch-diameter, cadmium-loaded polyethelene sphere with a BF_3 tube in the center for use as an area monitor. This detector has been shown to have an energy response which closely follows the theoretical dose from neutrons over the energy range from 0.025 eV (thermal) to about 10.00 MeV.[1] [2] The BF_3 tube allows excellent gamma rejection.

B. SPECIFICATIONS

Detector: BF_3 tube in nine-inch cadmium-loaded polyethelene sphere.

Plateau: Approximately 200 V with a slope of 5 percent per 100 V.

Operating Voltage: Dependent on sensitivity of counter and cable length. Typically 1600 to 2000 V.

Directional Response: Within ±10 percent.

Energy Range: Thermal to approximately 10 MeV.

Gamma Rejection: Up to 500 R/h, dependent on high voltage setting.

Sensitivity: Approximately 50 cpm per mrem per hour (3000 counts per mrem).

Connector: MHV Series coaxial.

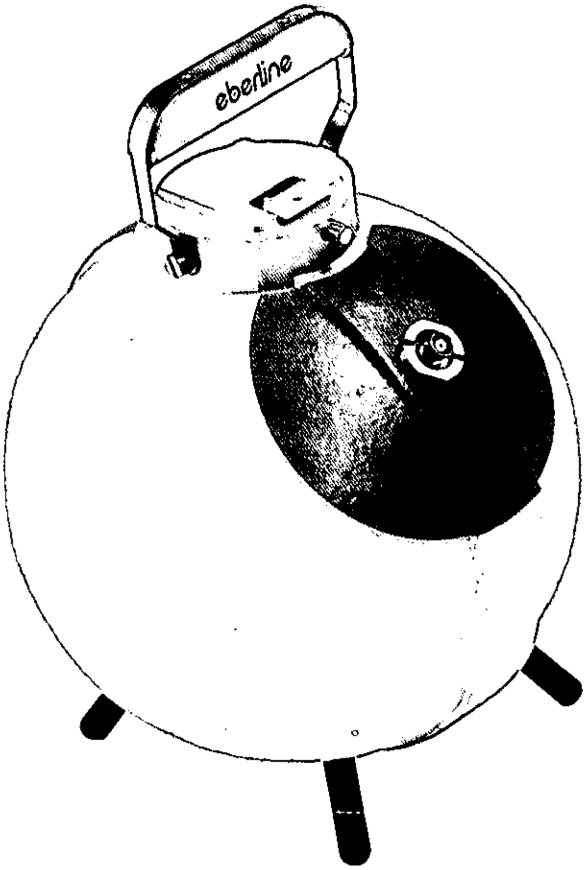
Size: 9-inch-diameter × $9\frac{7}{8}$-inch overall height (22.9 cm × 25.1 cm).

Weight: 13.75 pounds (6.24 kg).

C. AVAILABLE ACCESSORIES

Cable: CA-15-36

Bracket: Wall Mounting Model ZP10478021



NRD

- MEASURES NEUTRON DOSE RATE FROM THERMAL THROUGH FAST
- BF_3 TUBE GIVES HIGH GAMMA REJECTION

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[1] "A Modified Sphere Neutron Detector," D.E. Hankins, LA-3595.

[2] "The Substitution of a BF_3 Tube for the LiI Crystal in Neutron rem Meters". D.E. Hankins: *Health Physics Journal;* Volume 14, Number 5, May 1968.

Model HP-280
Neutron Sphere

A. GENERAL DESCRIPTION

The Model HP-280 is a three-inch-diameter cadmium-covered polyethylene sphere which uses the same BF_3 tube as the NRD nine-inch sphere. HP-280 readings are to be taken with the same tube as the NRD. No tube is supplied with the HP-280.

The cadmium covering over the HP-280 will cause the detector to reject thermal neutrons. Because of the smaller moderating volume of polyethylene of the HP-280, it will overrespond to lower energy neutrons and underrespond to higher energy neutrons as compared to the nine-inch sphere. Thus, in the energy range in which the HP-280 responds, a ratio of reading between the nine-inch and three-inch spheres will give information as to the energy spectrum of the neutron flux.

This energy information has been correlated to the energy dependence of the albedo neutron TLD dosimeter (see references 1 and 2 below). This energy correlation is shown as a calibration factor which would be applied to the neutron response of an albedo dosimeter.

For a more complete understanding of the phenomenon described above, refer to the following papers:

"A Modified Sphere Neutron Detector," D.E. Hankins, LA-3595.

"The Substitution of a BF_3 Tube for the LiI Crystal in Neutron rem Meters." D.E. Hankins: *Health Physics Journal;* Volume 14, Number 5, May 1968.

B. SPECIFICATIONS

Detector: BF_3 tube is not supplied with this sphere. Use the same tube as in nine-inch sphere.

Electronics: Suitable for use with many Eberline counters and scalers.

Length: Approximately 6¼ inches (15.9 cm).

Weight: 2 pounds (0.91 kg) less detector tube.

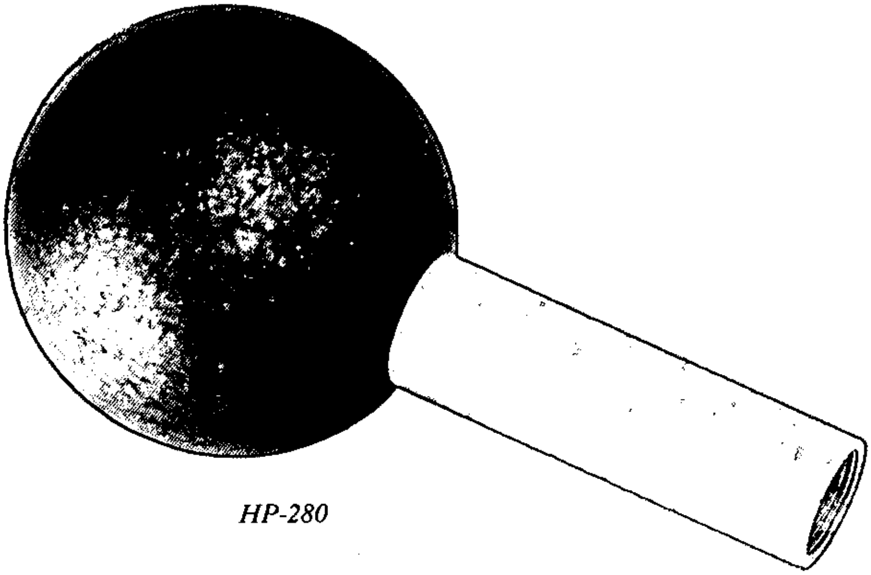
Calibration with Monoenergetic Neutrons
by National Bureau of Standards

Energy, keV	Typical Response of Instrumnet (cpm per mrem/h)	
	NRD	HP-280
2	215	1835
24	240	1320
144	80	200
235	70	160
515	35	35
754	35	25
1054	35	15

C. AVAILABLE ACCESSORIES

Detector: BF_3 Tube

Cable: CA-15-36



HP-280

Model AC-3
Alpha Scintillation Probe

A. GENERAL DESCRIPTION

To meet the various requirements in the field of alpha monitoring and the different types of instruments, the AC-3 alpha scintillation probe has been designed for alpha surveys or for personnel monitoring. The AC-3 is a rugged alpha probe designed to work with several Eberline portable survey or radiation monitoring instruments.

There are two versions of the AC-3, differing only in the window assembly. The AC-3-7 designates a maximum open area window for alpha surveys, and the AC-3-8 designates a rugged window which has a fine mesh protector over the Mylar® for personnel monitoring.

The Mylar® window is a "sandwich" assembly which can be replaced by the removal of six screws. This window can also be used on older AC-3 probes without modification.

There is a clear plastic probe face cover supplied to protect the window when the probe is not in use.

B. SPECIFICATIONS

Active Area: 9.1-in^2 ($59\ \text{cm}^2$) within 5.75-inch × 2-inch (14.6 cm x 5.1 cm) sampling area.

Window Thickness: $0.5\ \text{mg/cm}^2$ aluminized Mylar®

Efficiency: From a 1-inch-diameter source or from $59\ \text{cm}^2$ of a large distributed area ^{239}Pu source (2π).

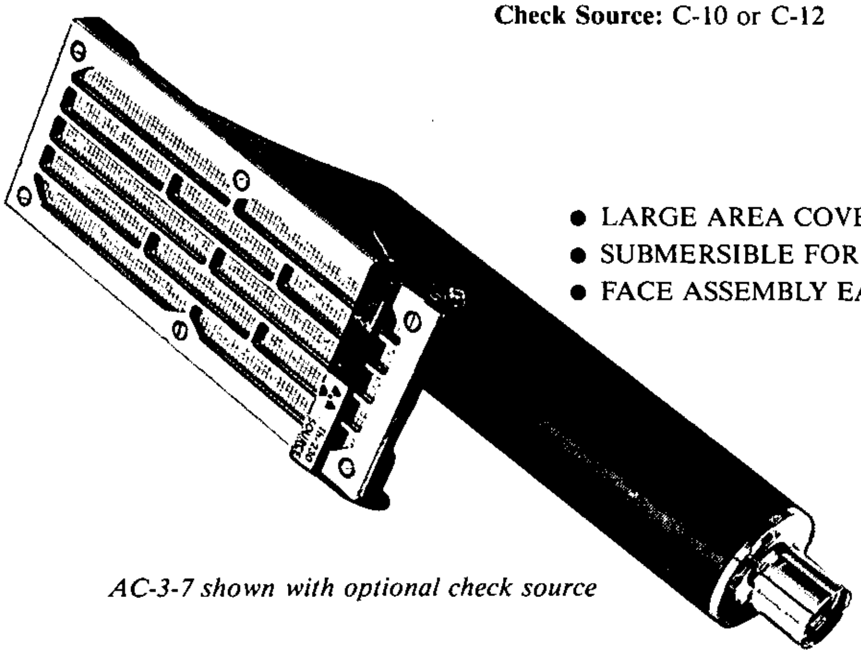
AC-3-7 window: 28 percent minimum,
31 percent typical.

AC-3-8 window: 18 percent minimum,
20 percent typical.

C. ACCESSORIES

Cable: CA-12-60

Check Source: C-10 or C-12



- LARGE AREA COVERAGE
- SUBMERSIBLE FOR DECONTAMINATION
- FACE ASSEMBLY EASILY CHANGED

AC-3-7 shown with optional check source

Model LEG-1
Low-Energy Gamma Probe

A. GENERAL DESCRIPTION

The LEG-1 is a gamma scintillation probe for detection of low-energy gamma and x-rays. It is designed for the detection of ^{125}I and other low-energy gamma emitters.

B. SPECIFICATIONS

Crystal: 1-inch-diameter × 0.04-inch-thick with 0.001-inch window (2.54-cm-diameter × 1-mm-thick NaI(Tl) scintillation crystal with a 0.025-mm aluminum window). The total window thickness of the probe, including the housing, is 0.011 inch (0.28 mm) aluminum or 75.4 mg/cm^2.

Sensitive Area: 0.79 in^2 (5.1 cm^2)

Photomultiplier Tube: 1-inch-diameter (2.54 cm), 11-dynode with S11 response. The PM tube is enclosed in a magnetic shield.

Maximum Voltage: 1500 V

Operating Voltage: Variable depending upon application.

Current Requirement: Divider string is approximately 110 MΩ, using 10 μA at 1100 V.

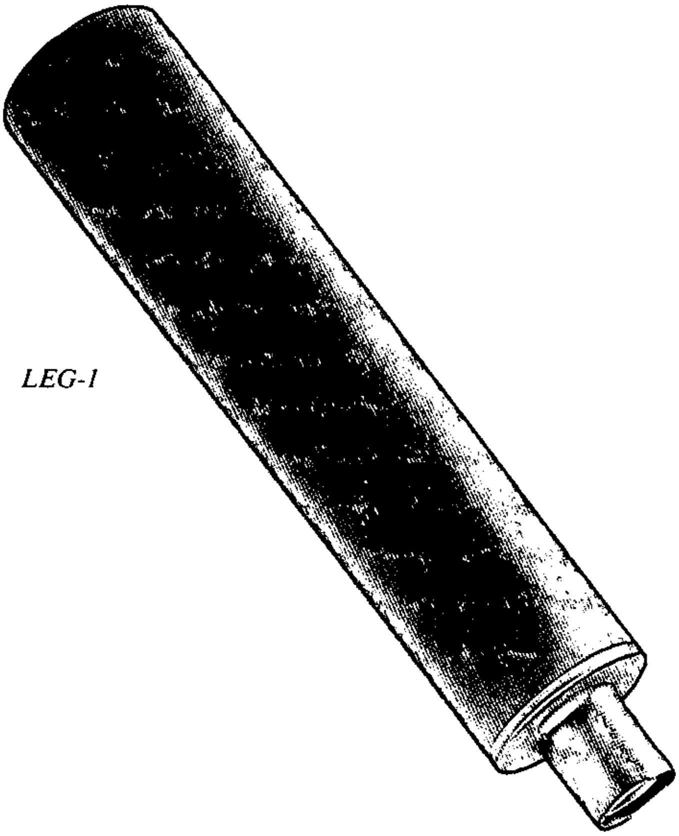
Dimensions: 1.65 inches in diameter × 7.9 inches long (4.2 cm × 20 cm).

Weight: 12 ounces (340 g)

Connector: Eberline CJ-1 which mates with Eberline CP-1. Cable must be specified.

C. AVAILABLE ACCESSORIES

Cable: CA-12-60



LEG-1

Model SPA-3
Scintillation Probe

A. GENERAL DESCRIPTION

The Model SPA-3 scintillation probe is a rugged, waterproof gamma detector designed for high sensitivity of pulse-height applications.

The SPA-3 contains a 2-inch-diameter, 2-inch-long NaI(TI) crystal, a 2-inch, 10-stage photomultiplier tube, tube socket with a dynode resistor string, and a magnetic shield.

B. SPECIFICATIONS

Crystal: NaI(TI), 2-inch-diameter × 2 inches long (5.1 cm × 5.1 cm).

Photomultiplier Tube: ≅2-inch-diameter, 10-dynode, end-window with S-11 photocathode.

Operating Voltage: Variable dependent upon application.

Maximum Voltage: +1600 V

Sensitivity: ≅1200k cpm per mR/h with ^{137}Cs

Current Drain: ≅120 MΩ resistance string yields 10 μA at 1200 V.

Wall Material: Aluminum

Wall Thickness: 1/8-inch (0.32 cm), 1/16-inch (0.16 cm) at crystal.

Connector: Mates with Eberline CP-1.

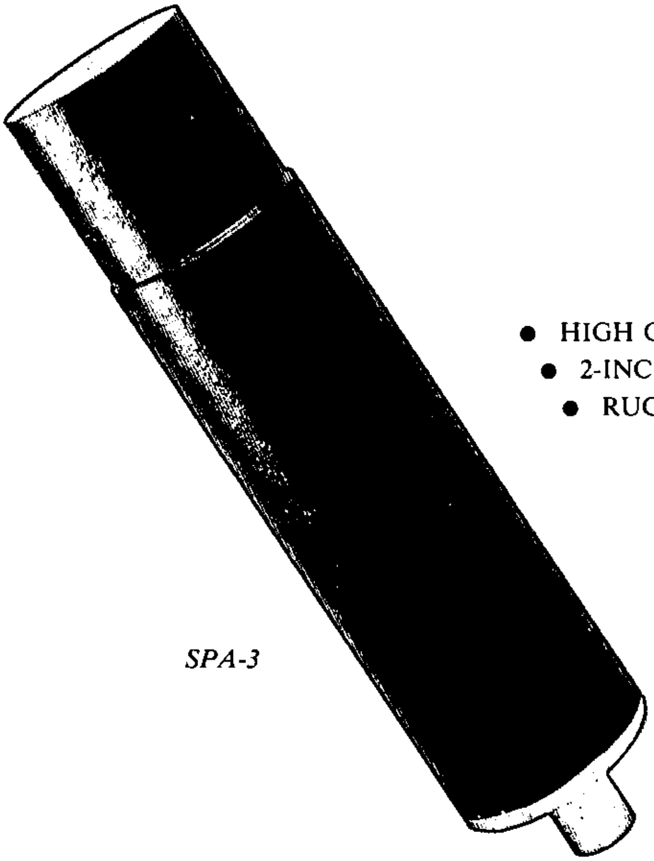
Finish: Enameled body with chrome-plated connector.

Size: 2 5/8-inch-diameter × 11 1/8 inches long (6.7 cm × 28.3 cm).

Weight: 3.25 pounds (1.5 kg)

C. AVAILABLE ACCESSORIES

Cable: CA-12-60



SPA-3

- HIGH GAMMA SENSITIVITY
- 2-INCH × 2-INCH NaI(TI) CRYSTAL
- RUGGED CONSTRUCTION

Model HP-190-A
Hand Probe

A. GENERAL DESCRIPTION

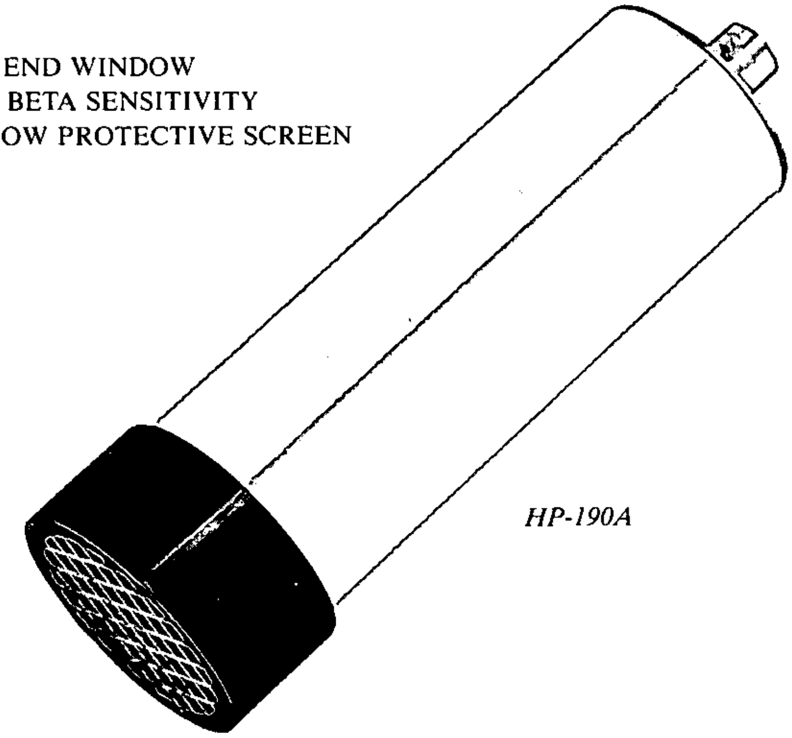
The Model HP-190A hand probe uses a thin end-window GM tube for detection of relatively low energy beta and provides a limited sensitivity to high energy alpha particles. The HP-190A does not have energy compensation; therefore, it is not recommended for gamma exposure rate measurements.

B. SPECIFICATIONS

Operating Voltage: 900 ± 50V
Plateau Length: 100 V minimum
Plateau Slope: 0.1 percent per V maximum
Dead Time: 200 μs maximum
Temperature Range: −67° F to +167° F (−55° C to +75° C)
Mica Window Thickness: 1 1/8- inch-diameter (2.9 cm)
Gamma Sensitivity: $\cong$2500 cpm/mR/h (^{137}Cs) (into window)
***Beta Efficiency:**
  $\cong$35 percent ^{90}Sr-^{90}Y
  $\cong$25 percent ^{99}Tc
  $\cong$10 percent ^{14}C
Alpha Sensitivity: 3 MeV at window
Connector: BNC series coaxial
Size: 1 3/8 inches in diameter × 4 7/8 inches long (3.5 cm × 12.4 cm)
Weight: 5.5 ounces (155 g)

*Measured without screen cap. With cap in place, efficiency will be $\cong$50 percent of values listed. Efficiencies listed as percent of 2π emission rate from a one-inch-diameter source.

- THIN END WINDOW
- HIGH BETA SENSITIVITY
- WINDOW PROTECTIVE SCREEN



HP-190A